Performance Properties of Polyetherimide: A Review

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Abstract- **The purpose of this research paper is fabrication of polyetherimid (PEI) reinforced with glass fiber and graphite powder and to study two types of wear (i.e adhesive and abrasive wear) of PEI composites with different percentages of graphite powder. Polyetherimide(PEI) composites with fiber contents 55 wt.% are fabricated using compression molding technique. (ULTEM 1000) in granules form is one of the newest high-performance thermoplastics. Wear behavior of glass fibre reinforced PEI composites with different percentage of graphite powder is observed on pin on disc apparatus at different loads.**

I. INTRODUCTION

A composite is a structural material that consists of two or more combined constituents that are combined at a macroscopic level and are not soluble in each other. One constituent is called reinforcing phase and one in which it is embedded is called the matrix. The reinforcing phase material may be in the form of fibers, particles or flake. The matrix phase materials are generally continuous. Examples of naturally found composites include wood, where the lignin matrix is reinforced with cellulose fibers and bones in which the bone-salt plates made of calcium and phosphate ions reinforce soft collagen. The roles of matrix in composite materials are to give shape to the composite part, protect the reinforcements to the environment, transfer loads to reinforcements and toughness of material, together with reinforcements. The aim of reinforcements in composites are to get strength, stiffness and other mechanical properties, dominate other properties as coefficient of thermal extension, conductivity and thermal transport.

Composite materials can be classified in different ways [5]. Classification based on the geometry of a representative unit of reinforcement is convenient since it is the geometry of the reinforcement which is responsible for the mechanical properties and high performance of the composites.The two broad classes of composites are.

(1) Particulate composites

(2) Fibrous composites

1.1 Particulatecomposite: As the name itself indicates, the reinforcement is of particle nature (platelets are also included in this class). It may be spherical, cubic, tetragonal, a platelet, or of other regular or irregular shape, but it is approximately equiaxed. In general, particles are not very effective in improving fracture resistance but they enhance the stiffness of the composite to a limited extent. Particle fillers are widely used to improve the properties of matrix materials such as to modify the thermal and electrical conductivities, improve performance at elevated temperatures, reduce friction, increase wear and abrasion resistance, improve machinability, increase surface hardness and reduce shrinkage.

1.2 Fibrous composites: A fiber is characterized by its length being much greater compared to its cross-sectional dimensions. The dimensions of the reinforcement determine its capability of contributing its properties to the composite. Fibers are very effective in improving the fracture resistance of the matrix since a reinforcement having a long dimension discourages the growth of incipient cracks normal to the reinforcement that might otherwise lead to failure, particularly with brittle matrices.

Constituents of composites

1. Matrices
2. Reinforcing Fibers
3. Filler materials

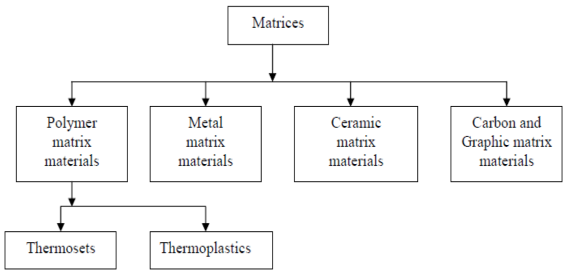

Figure.1. classification of matrices

The role of matrix in a fiber-reinforced composite is to transfer stress between the fibers, to provide a barrier against an adverse environment and to protect the surface of the fibers from mechanical abrasion. The matrix plays a major role in the tensile load carrying capacity of a composite structure. The binding agent or matrix in the composite is of critical importance.

II. LITERATURE REVIEW

In this section the various developments in this field in last 10 years are listed with their results and conclusions.

J.bijwe, J.Indumathi 2001

They selected a high performance engineering polymer, polyetherimide and its two composite one containing only short glass fiber (20%) and the other containing 25% glass fiber and three solid lubricants for studying the four types of wear. The addition of solid lubricants has improved the adhesive wear resistance but the abrasive wear increased with addition of fillers against SiC papers.

U.S.TIWARI et al. 1992
This paperstates that Polyetherimide is one of the newest high-performance thermoplastics. Its graphite and short-glass-fibre (GF) filled composition was evaluated for friction and wear properties. Tribological studies of the material sliding against mild steel, under different loads, counter face roughness and sliding distances were performed on a pin and disc configuration. He observed that this composite displayed very good wear resistance due to glass-fibre reinforcement and low friction due to the solid lubricant graphite. The wear mechanism was studied with scanning electron microscopy by observing the worn pin and disc surfaces. Fatigue was observed to be the main factor in wear, along with adhesive and abrasive modes.

J.VINA et al. 2008
investigated the wear behavior of a thermoplastic polymer, polyetherimide, and of a composite with this polymer as matrix and a reinforcement of glass fiber. The investigation shows that the reinforced material has higher wear strength then the non-reinforced material. The effect of temperature on wear performance is also studied which shows that when the temperature is increased the wear was increased, except to 2000C . At 2000C there was an important decrease because it would be close to glass transition temperature of the polymer (2170C) which causes micro-structural variation in the material.

A.P.HARSHA et al.2007
This research paper investigated the solid particle erosion behavior of randomly oriented short E-glass, carbon fiber and solid lubricants (PTFE, graphite, MoS2) filled polyetherimide (PEI) composites. The erosion rates of these composites have been evaluated at different impingement angles (15-900) and impact velocities (30-88 m/s). Polyetherimide and its glass, carbon fiber reinforced composites showed semi-ductile erosion behavior with peak erosion rate at 600 impingement angle. However glass fiber reinforced PEI composite filled with solid lubricant showed peak erosion rate at 600 impingement angle for impact velocities of 30 and 88 m/s. whereas for intermediate velocity (52 & 60 m/s) peak erosion rate observed at 300 impingement angle. It is observed that 20% glass fiber reinforcement helps in improving erosive wear resistance of neat PEI matrix.

Guijun Xian et al.
This research studied the sliding wear of graphite flake filled polyetherimide against polished steel counter parts at various temperatures. The addition of 5 -20 vol. % of graphite contributed to an obvious improvement of tribological performance of PEI at either room temperature or elevated temperature (up to 2200C). Higher filler content (≥ 15 vol. %) leaded to a very low coefficient of friction when temperature exceeded 1500C. the specific wear rate was also reduced. Microscopy studies suggested that friction films were formed on both the counterpart and the worn surface of composite. An interface layer is formed between the friction films at elevated temperature for high content graphite filled composites, which contributes to the unusual improvement of wear properties.

Klaus Friedrich et al. 2005
in his research, he has a particular emphasizes on special filler reinforced thermoplastic and thermosets. The effect of particle size and filler contents on the wear performance was summarized. He observed that once the particle sizes are diminishing down to nano scale significant improvements of wear resistance of polymer were achieved at very low nano filler content (1-3 vol. %).

V. K. Srivastava et al.
In this research the effect of particulate additions on the friction and wear of short glass fiber reinforced epoxy resin composites was investigated. Particles of graphite were mixed with the epoxy resin prior to composing with short glass fiber. Tests were performed on bushing samples to obtain the friction and wear for the composites with varying applied load and sliding time. It was found that graphite has an important impact on the wear and friction properties of glass fiber reinforced epoxy resin composites. It is clear that after an incubation period, there is a nearly linear relationship between wear load and sliding time. Wear increases with load and time, but as the amount of graphite in the composite increases, its value decreases irrespective of the applied load and sliding time, due to increase of wear resistance in matrix materials. However, friction increases only with sliding time but decreases with the increase of graphite particles irrespective of time.

Li Chang et al. 2007
In this research it was found that conventional fillers, i.e. SCF and graphite flakes, could effectively enhance both the wear resistance and the load-carrying capacity of the base polymers. With the addition of sub-micro particles, the frictional coefficient and wear rate of the composites were further reduced especially at elevated temperatures. On the basis of microscopic observation of worn surfaces, dominant wear mechanisms are discussed.

J. bijwe et al. 2006
In this research three weaves (plain, twill and woven) of glass fiber as reinforcement for developing composites based on polyetherimide matrix composite containing additional filler was formulated to investigate the influence of fillers on wear performance. It was observed that plain weave proved to be best effective in enhancing the wear behavior of PEI three times. Twill weave and fillers, however, performed poorly resulting significant deterioration in wear performance while woven fabric showed some improvement in wear performance at higher loads. Mechanical properties of the composites did not support the trend in the wear behavior.

SudhirTiwari, et al 2011
This research studied the influence of plasma treatment on Carbon Fabric for enhancing Abrasive Wear Properties of

PEI Composites. Interfacial adhesion between matrix and fibre plays a crucial role in controlling performance properties of composites. Carbon fibres have major constraint of chemical inertness and hence limited adhesion with the matrix. Surface treatment of fibres is the solution of the problem. In this work, cold remote nitrogen plasma (CNROP) was used for surface treatment. Twill weave carbon fabric (55-58%) was used with and plasma treatment with varying content of oxygen (0-1%) in nitrogen plasma to develop composites with PEI composites.

III. CONCLUSIONS

In the above literature review section the wear behavior of PEI & PEI reinforced with glass fibre has been discussed. The addition of solid lubricants has improved the adhesive wear resistance but the abrasive wear increased with addition of fillers against SiC papers.[1]Fatigue is the main factor that results in the wear along with other wear modes.[2] Behavior of thermoplastic polymer it shows that the reinforced material has higher wear strength then the non-reinforced material [3]. It is observed that 20% glass fiber reinforcement helps in improving erosive wear resistance of neat PEI matrix.[4]The particle sizes are diminishing down to nano scale significant improvements of wear resistance of polymer were achieved at very low nano filler content (1-3 vol. %).[6]. Mechanical properties of the composites did not support the trend in the wear behavior [8] .Mechanical properties of the composites did not support the trend in the wear behavior.[9]

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