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Determination and Analysis of Wear Performance of Peek with Reinforced MWCNT

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Abstract: peek is a high performance semicrystalline the rmoplastic, which is now-a-days used as a replacement of metal matrix due to their excellent thermal and wear properties. Reinforced peek are materials of significance for the aeronautical and automobile industry due to their outstanding mechanical properties, chemical properties wear resistance, and thermal properties. Polyether-ether-ketone (peek) becomes one of the most promising polymer materials for the tribological applications. In the present investigation, the peek is mixed with mwcnt (0.5%wt and 1%wt) and the materials are prepared through multi mix injection moulding. The wear loss of the peek and peek with reinforced mwcnt is calculated manually under varying temperatures, speeds, and loads with fixed sliding distance using pin on disc apparatus under dry sliding condition. The morphology of the worn surface of the pin is observed from scanning electron microscope (sem).

keywords: peek; multi wall carbon nano tubes (mwcnt); injection moulding; pin on disc: scanning electron microscopy (sem)

I. INTRODUCTION

The high performance poly (ether-ether-ketone) (PEEK) polymer was first prepared by Bonner in 1962 [1]. The inclusion of inorganic fillers into polymers for commercial applications is primarily aimed at the cost reduction and stiffness improvement [2]. The inorganic nano fillers, ranging from 1 to 50 nm, were successfully incorporated into the polymeric matrix to strengthen and improve the ductile polymer to be more stiff and resistant for abrasion [3]. Nano particle-filled PEEK composites have been successfully fabricated by means of compression molding process [4]. The PEEK composites are commonly used in tribo applications due to the combination of thermomechanical properties and relatively low friction and wear [5]. The addition of short fibers to unreinforced thermoplastics further increases stiffness, strength, hardness, and service temperature [6]. The carbon and glass fibers are the common reinforcements in thermoplastics because of their low-expansion rate and their high-flexural modulus. The carbon fiber reinforcement provides maximum rigidity and load bearing capacity [7] the tribological behavior of potassium titanate whiskers (PTW) reinforced PEEK composite has been investigated using the pin-on-disk configuration at different applied loads under water lubricated condition [8]. Paulo Davim and RosáriaCardosoIn have used statistical techniques to study the effects of temperature and sliding distance on the dry sliding tribological behaviour of 30 wt% carbon-fibre-reinforced PEEK composite [9]. Friedrich et al [10] have found that an increase in testing temperature resulted in higher specific wear rates and in lower friction coefficients for PEEK-CF30 (wt%). Hanchi and Eiss [11] have studied the friction and wear of PEEK-CF30 (wt %) at elevated temperatures. The reinforcement with carbon fibres increased the mechanical resistance with the temperature. As temperatures increased from below to above the glass transition temperature (Tg) of the polymer matrix, the wear performance of the composite was seen to deteriorate and the friction was seen to decrease appreciably. The orientation of crystals is another important parameter in microstructure and plays important role in mechanical and tribological properties of PEEK and its composites [12]. The review of above literature revealed that the studies on microstructure and properties of PEEK and PEEK reinforced CNT composites is very limited and it left the scope to the authors to study the polymer nano composites. Therefore in the present investigation, the mechanical performance of PEEK and its composites is studied. The microstructure of the samples are studied by using scanning electron microscopy (SEM).

II. BACKGROUND THEORY

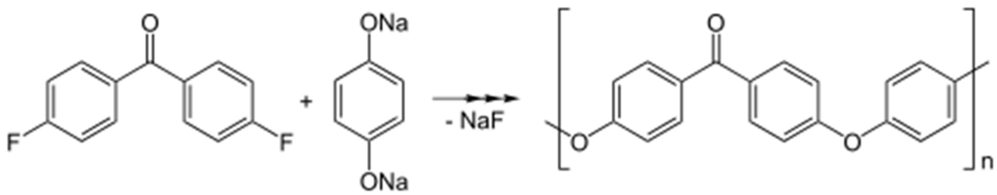
A. Polyether ether ketone

Polyether ether ketone (PEEK) is a colorless organicthermoplasticpolymer in the polyaryletherketone (PAEK) family, used in engineering applications. The high performance poly (ether-ether-ketone) (PEEK) polymer was first prepared by Bonner in 1962

[1]. The inclusion of inorganic fillers into polymers for commercial applications is primarily aimed at the cost reduction and stiffness improvement [2].

B. Synthesis

PEEK polymers are obtained by step-growth polymerization by the dialkylation of bisphenolate salts. Typical is the reaction of 4,4'-difluorobenzophenone with the disodium salt of hydroquinone, which is generated in situ by DE protonation with sodium carbonate. The reaction is conducted around 300 °C in polar aprotic solvents such as diphenylsulphone.

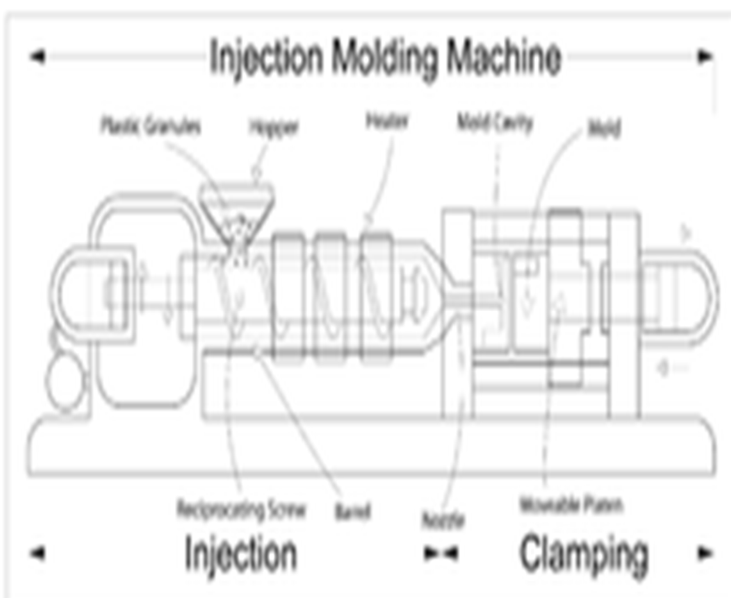


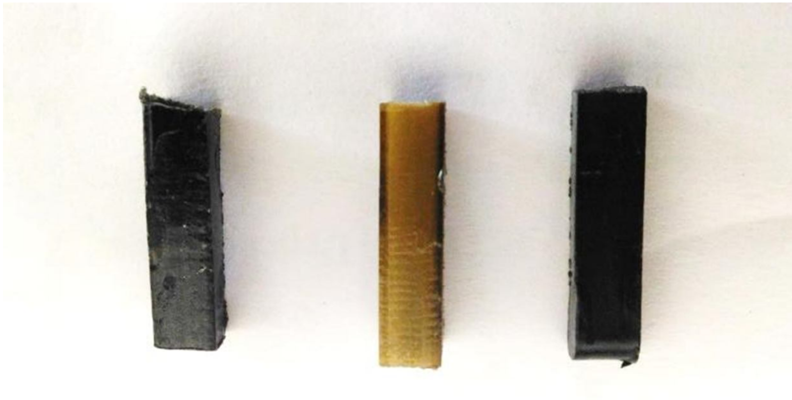
III. MATERIAL PREPARATION

A. Injection Moulding

Injection moulding is a manufacturing process for producing parts by injecting material into a mould. Injection moulding can be performed with a host of materials mainly including metals, (for which the process is called die-casting), glasses, elastomers, confections, and most commonly thermoplastic and thermosettingpolymers. Material for the part is fed into a heated barrel, mixed, and forced into a mould cavity, where it cools and hardens to the configuration of the cavity.[1]:240 After a product is designed, usually by an industrial designer or an engineer, moulds are made by a mould-maker (or toolmaker) from metal, usually either steel or aluminium, and precision-machined to form the features of the desired part. Injection moulding is widely used for manufacturing a variety of parts, from the smallest components to entire body panels of cars. Advances in 3D printing technology, using photopolymers which do not melt during the injection moulding of some lower temperature thermoplastics, can be used for some simple injection moulds.

Parts to be injection moulded must be very carefully designed to facilitate the moulding process; the material used for the part, the desired shape and features of the part, the material of the mould, and the properties of the moulding machine must all be taken into account. The versatility of injection moulding is facilitated by this breadth of design considerations and possibilities.





IV. WEAR ANALYSIS

Wear is a process of removal of material from one or both of two solid surfaces in solid state contact. As the wear is a surface removal phenomenon and occurs mostly at outer surfaces, it is more appropriate and economical to make surface modification of existing alloys than using the wear resistant alloys.

A. Experimental Procedure Of Wear Test

Dry sliding wear tests for different number of specimens was conducted by using a pin-on-disc machine (Model: Wear & Friction Monitor TR-20) supplied by DUCOM The pin was held against the counter face of a rotating disc (EN31 steel disc) with wear track diameter 90 mm. The pin was loaded against the disc through a dead weight loading system.

The pin samples were 30 mm in length and 6 mm in diameter. The surfaces of the pin samples were slides using emery paper (80 grit size) prior to test in order to ensure effective contact of fresh and flat surface with the steel disc. The samples and wear track were cleaned with acetone and weighed (up to an accuracy of 0.0001 gm using microbalance) prior to and after each test. The wear rate was calculated from the height loss technique and expressed in terms of wear volume loss per unit sliding distance.

1) In this experiment, the test was conducted with the following parameters

a) Load

b) Speed

c) Distance

d) Temperature

In the present experiment the parameters such as speed, time and load are kept constant throughout for all the experiments.These parameters are given in Table

S.No	Order	Load	Speed	Temperature (˚C)	Wt%MWCNT	Speed	Time in mins
1	18	10	0.63	120	0.5	201	13
2	28	10	3	90	0.5	955	3
3	6	50	3	60	0.5	955	3
4	26	50	0.63	120	0	201	13
5	13	30	3	60	0	955	3
6	21	50	3	90	0	955	3

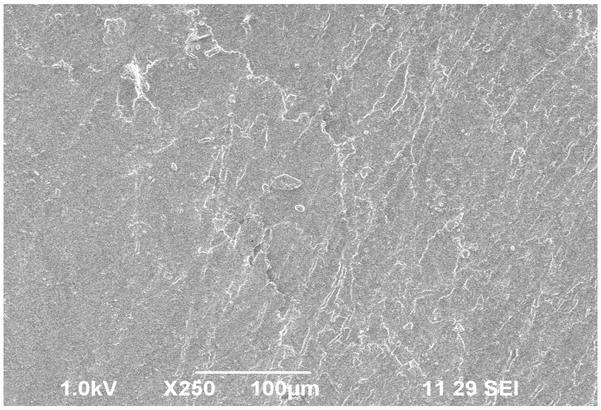
B. Weight Loss

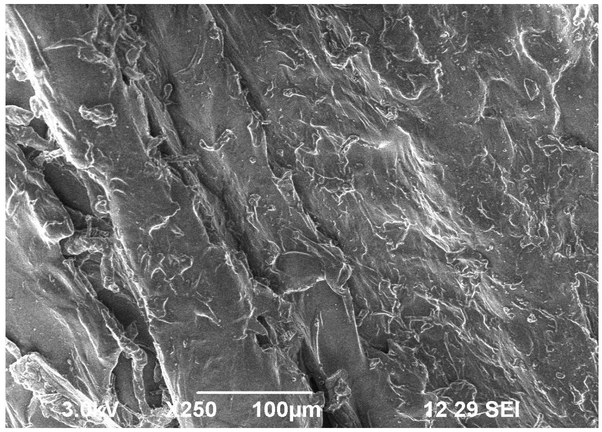
The alloy and composite samples are cleaned thoroughly with acetone. Each sample is then weighed using a digital balance having an accuracy of ± 0.1 mg. After that, the sample is mounted on the pin holder of the tribometer ready for wear test. For all experiments, the sliding speeds are adjusted to 2 and 4 m/s. The specific wear rates of the materials were obtained by W = w where W denotes specific wear rates in mm3/N- w is the weight loss measured in grams, density of the worn material in g/mm3 and F is the applied load in N.

V. SEM ANALYSIS

A. scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the sample's surface topography and composition. The electron beam is generally scanned in a raster scan pattern, and the beam's position is combined with the detected signal to produce an image. SEM can achieve resolution better than 1 nanometer. Specimens can be observed in high vacuum, in low vacuum, in wet conditions (in environmental SEM), and at a wide range of cryogenic or elevated temperatures.

The most common SEM mode is detection of secondary electrons emitted by atoms excited by the electron beam. The number of secondary electrons that can be detected depends, among other things, on specimen topography. By scanning the sample and collecting the secondary electrons that are emitted using a special detector, an image displaying the topography of the surface is created.





VI. CONCLUSION

The SEMimages reveals the morphology of the worn surfaces of the samples PEEK and PEEK with MWCNT (0.5%wt). The morphology shows that the reinforced PEEK has very less wear rate and hence has worn to a very little extent. Thus the MWCNT reinforced PEEK can be widely used in various fields of applications like aeronautical and automobile industry due to their outstanding wear performance.

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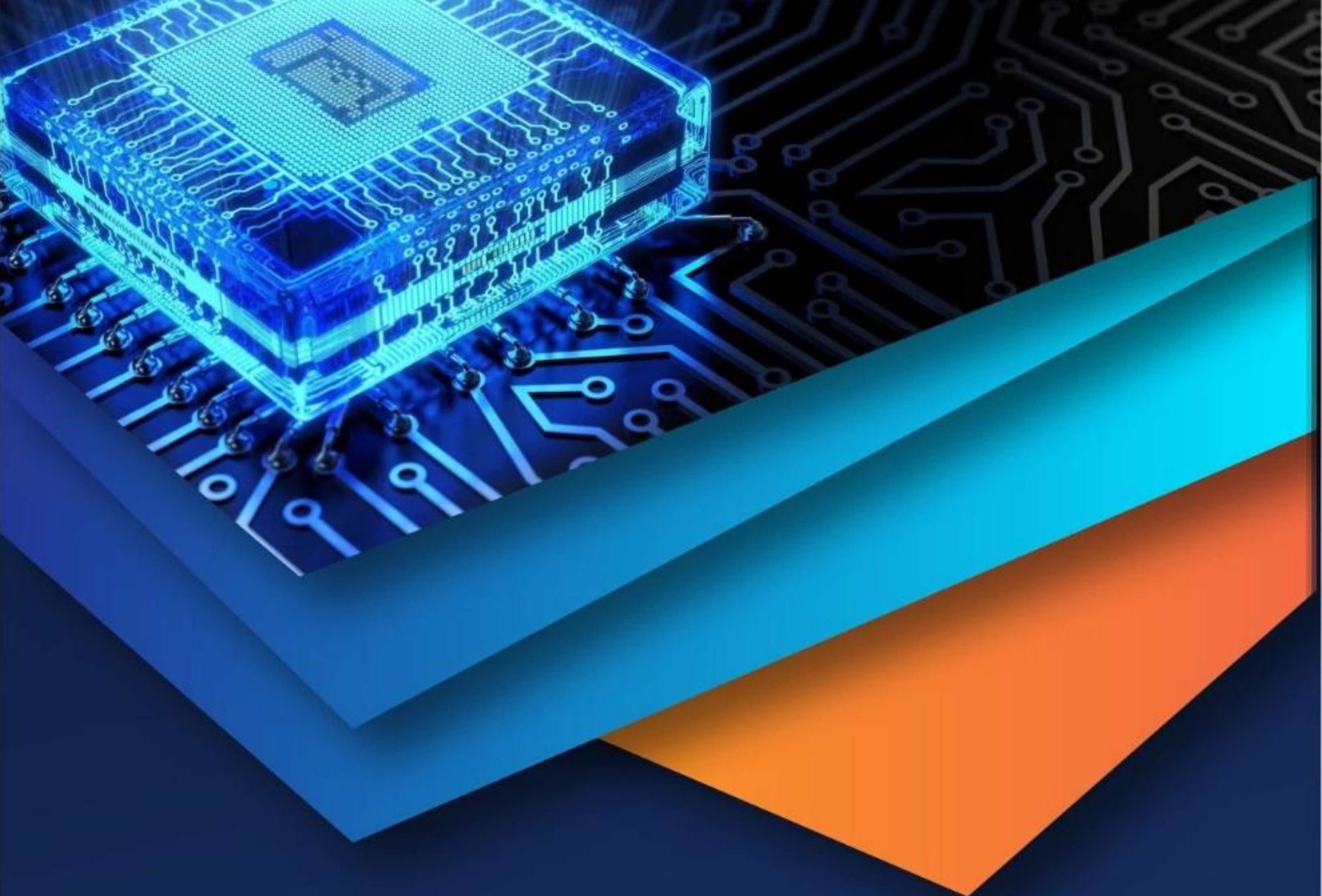

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