Faculty of Engineering
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Studying the Tribological Behavior of Reinforced Gears

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Statement

This Thesis is submitted in the partial fulfillment of master degree in Mechanical Engineering in Ain-Shames University .

The author carried out the work included in this thesis, and no part of this thesis has been submitted for a degree or qualification at any other university.

Signature

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Abstract

Gears made from polymers have been widely used in industrial applications due to several advantages such as weight reduction, self lubrication, noise reduction, cost saving and low tribological characteristics i.e. wear and friction coefficient.

The main objective of this research is to study the wear behavior of polyamide (Nylon6) reinforced with multi walled carbon nanotubes (MWCNTs) spur gears. The dispersion of MWCNTs was made by using paraffin adhesive oil during injection molding practice. MWCNTs were produced by using fully automatic system using an arc discharge technique multi electrodes. The MWCNT/Nylon flanges synthesized with various percentages of MWCNTs, i.e. 0.1%,0.2%,0.3% wt. The dispersion of carbon nanotubes inside composite is examined by high emission electron microscope . The specimens in form of spur gears are fabricated by a flanges of diameter 135 mm and thickness 29 mm which then produced by hopping machine. Mechanical and wear tests are conducted to evaluate the effect of MWCNTs as a reinforcement in Nylon6 for gears applications .

The results showed that a decrease in the wear rate for all spur gears are archived by adding MWCNTs, i.e. increasing the percentage of MWCNTs decreases the wear rate . In addition, increasing MWCNTs percentage results in an increase in strength, stiffness, hardness and modules of elasticity but decreases the elongation was property.

Structure of the M.Sc. Thesis

This research has investigated the wear and mechanical behavior after adding carbon nano tubes with different percentages as a reinforcement material to Nylon6 . The wear behavior was tested under two different external torque and different number of cycles using a modified test rig.

Chapter one Provides an introduction to the polymer reinforcement. In more details, the main challenges, the previous researches was carried on the polymer gears and the effect of adding carbon nanotubes as a reinforcement material. Also introduce the ways of blending and a different types of test rigs for wear testing ends by the problem statement.

Chapter two Introduces a full background about carbon nanotubes and its methods of synthesizing, applications.

Chapter three Shows the experimental setup to design and manufacture the mould and the test rig used for wear testing were explained also the different tests carried to the pure and the reinforced gears.

Chapter four Shows the results and the discussion of the results of the tests carried out in chapter three

Chapter five Introduces the conclusions, future work and some recommendations.

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Nomenclature

List of abbreviations

ESDU	Engineering Science Data Unite
CNT	Carbon nanotubes
MWCNT	Multi Wall Carbon Nanotubes
SWCNT	Single Wall Carbon Nanotubes
CCVD	Combustion Chemical Vapor Deposition
PTFE	Polytetrafluoroethylene
PNC	Polymer Nano Composite
POM	polyoxymethylene
CVD	Chemical Vapor Deposition
APCVD	Atmospheric Pressure Chemical Vapor Deposition
LPCVD	Low Pressure Chemical Vapor Deposition
HRTEM	High Resolution Transmission Electron Microscope
SEM	Scanning Electron Microscope
MIT	Massachusetts Institute of Technology
ITO	Indium Tin Oxide
PDA	Personal Digital Assistants
ATM	Automatic Teller Machine
OPV	Organic photovoltaic devices
ASTM	American Society For Testing and Material
HRH	Hardness Rockwell Test (H Scale type)
MK I	First test rig designed for polymer gears by Moe

List of Symbols

Ar	Argon
He	Helium
Fe	Iron
Co	Cobalt
N	Nitrogen
Nd YAG	Neodymium-doped yttrium aluminum garnet ($Y_3Al_5O_{12}$)
Ni	Nickel
Pt	Platinum
SP^2	Double Bond (S orbit)
Li	Lithium

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CHAPTER 1

LITERATURE REVIEW

Polymer science was found toward the end of seventeenth century, this date makes an unrest in the exploration of sound chronicle, conductive polymers, lighted polymers and other a few fields. Carbon, hydrogen, oxygen, as well as silicon are considered the primary unit for polymer structures. These units can be handled by heat and pressure into significant articles by using implantation machines or presses. At present, with frightful improvement in the designing enterprises and increment the usage rate of polymeric materials in numerous applications, for example, biomedical, flying machine, car, chemicals and vessel as polymer materials have a few favorable circumstances, for example, lighter, calmer, quicker, stronger, and cost effective, novel layouts logically fuse the use of unrivaled plastics. In this manner, it ended up noticeably vital build up these materials to keep pace with the advance in these ventures through another science has been found toward the finish of the most recent century called nanotechnology [1].

1.1 Polymer Gears

As of late, polymer composites were progressively utilized as a part of tribological applications to supplant metallic materials attributable to their simple manufacturability and phenomenal wear resistance[2] On the other hand, polymer composites are utilized for some basic machine components. The considerable share of them are shaped from unreinforced polymers-for the most part polyoxymethylene (Acetal) or polyamide (Nylon) [3]. Gears are generally utilized as a part of motion and power transmission under various speeds and loads [4].