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Polymer nanocomposites development and research for petrochemical and oil and gas production equipment

Y.K.Mashkov, V.A.Egorova*, O.V.Chemisenko, O.V.Maliy

Omsk State Technical University, pr. Mira, 11, Omsk, 644050, Russian Federation

Abstract

The research and development results of new anti-friction polymer nanocomposites based on polytetrafluoroethylene characterized with an increased wear resistance due to the polymer matrix with complex fillers-modifiers modification are presented in the paper. Fillers include micro- and nanoscale components of different nature and the particles geometry having specific surface and surface free energy high values. These factors provide the polymer matrix high-performance structural modification and significant increase in nanocomposites wear resistance in dry boundary friction.

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Keywords: polymer nanocomposites, carbon nanotubes, white carbon, cryptocrystalline graphite, polytetrafluoroethylene, wear resistance.

1. Introduction

New anti-friction wear-resistant polymeric composite materials (PCM) creating is one of the most important scientific-technical tasks for the oil and gas industry modern equipment production. The problems successful solution requires composite materials mechanical and tribological properties characteristics constant improvement produced for the petrochemical and oil and gas production operating in extreme conditions process equipment nodes.

The PCM data development promising direction is to create polymer nanocomposites based on polytetrafluoroethylene (PTFE) with polymer matrix and fillers structural modification of various types and particle dimensions: disperse, fiber, and in recent years nanoscale [1-2].

* Corresponding author. Tel.: (3812) 65-22-92;
E-mail address: omgtu_physics@mail.ru

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2. Study subject

Effective filler for antifriction application is PTFE Microfine cryptocrystalline graphite (CCG) of natural origin mark GLS-3 [3, 4] which is included into the filler complex [2, 4, 5]. We determined that composite materials with nanoparticles fillers - nanocomposites - have properties significantly different from the composites with macro- and micro-sized fillers due to the nano-sized filler particles higher surface energy and structural activity [5-8].

Considering the preliminary studies results [2-6] nanocomposites samples were investigated with various complex fillers to determine the composition and optimum concentration of different nature and particles shape nanomodifiers providing PCM performance characteristics predetermined level. The first composite was micro-powder CCG 8 wt. %, and Arkemac company Graphistrength brand carbon nanotubes (CNTs) in the amount of 2 wt.%. The second composite also contained CCG in the amount of 8 wt.% and brand BS-120 nanosized silica dioxide powder in an amount of 2 wt.%. Samples for the study were prepared with cold pressing and free sintering technology [1].

3. Results and discussion

The developed nanocomposites mechanical properties research was carried out: tensile limit $\sigma_в$, elasticity modulus in tension E and percentage elongation ε at tensile machine "Zwick/Roell" in accordance with GOST 11262-80 "Plastics. Test methods for stretching" procedures. Results are presented in Table 1.

Table 1.

PCM composition	$\sigma_в$, MPa	E, MPa	ε, %
CCG – 8%, CNT-2.0%,PTFE- 89.5%	15.2	158	137
CCG – 8%, BS-120 -2.0%,PTFE- 89.5%	15.1	105	113

The results (Table 1) show that the PCM with powdered nanomodifiers BS-120 has almost the same strength limit $\sigma_в$ with nanocomposite which is composed of carbon nanotubes. In this case the composite with fiber nanomodifier elasticity and elongation modulus has higher values at 50.4% and 21.2% respectively. It indicates that fiber and disperse modifiers introduction into a polymer matrix leads to different supramolecular nanostructures matrix formation. The fiber modifier use in the carbon nanotubes form is technologically difficult. CNTs form conglomerates impeding to nanotube uniform distribution in the matrix which are packed into tight bundles consisting of a single tube, and it greatly reduces the structural modification effectiveness and does not lead to a noticeable increase in PCM strength. Silica dioxide nanoparticles have different geometrical shape and undergo phobotex process at the synthesis modifier step, which prevents SiO_2 particles conglomerates formation. When the same PCM synthesis technology type uses silicon dioxide powder BS-120 brand it provides more uniform particles distribution in the matrix compared with the CNTs distribution. At the same time reducing the nanocomposite with BS-120 elastic modulus is not a disadvantage for PCM tribological application because when the composite is used for the tribosystems sealing members manufacture the material decrease rigidity enhances the sealing tightness degree.

In order to establish the silica dioxide optimal concentration in the developed PCM composites mechanical properties were investigated ranging BS-120 powder concentrations from 1 to 3 wt.% at CCG 8 wt. % constant concentration.

The developed composite material mechanical properties study results (Fig. 1) show that with nano-component BS-120 increasing concentration up to 3.0 wt.% the tensile strength slightly and monotonously decreases, while elongation is decreased by 41.7%, and elasticity modulus increased by 19.6%.