INFLUENCE OF GRAPHENE NANOFLAKES ADDITION ON GREASE TRIBOLOGICAL PROPERTIES

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1. Introduction

The issue of the friction is extremely economically important. There are estimations that 1/3 of all energy is wasted due to the friction [1-2]. Moreover, friction paired surfaces wearing leads to the loss of functionality and destruction of elements. Various treatments are undertaken to reduce the adverse effects of friction. The most widespread ways of decreasing such effects are the application of lubricant between friction paired surfaces and protective coating of such surfaces.

Considering the economic importance, studies were carried out to verify usefulness of graphene (material known for very good thermal conductivity and mechanical properties) as a material improving the tribological properties of surfaces or lubricants. The studies have focused on two ways of graphene use: as a protective layer and as an additive (nanoplatelets) to standard lithium grease. Such papers present results of studies on usefulness of graphene nanoplatelets as an additive to grease. Results of studies on using graphene as a protective layer were presented in the papers [3-4].

There are known results of studies on using graphene to improve tribological properties of grease [5-10]. In the paper the unique methodology of research and test stand which allows to evaluation of the usefulness of graphene additive to grease in macroscale in conditions similar to typical work conditions of devices was presented.

2. Test stand and experiment methodology

The study was conducted on a unique designed test stand. Its construction is presented in fig.1. In the central part of the test stand three samples (2) were kept in place by dedicated holders (3). During tests there was relative movement between surfaces of such samples (2) and ring-shaped track (1). Between track (1) and samples (2) grease could be applied. Pressure between samples (2) and track (1) was provided by weights (6). Elements (4, 5, 7) transmitted the load to friction pairs. Force sensor (8) blocked the rotation of the samples (2) and elements (3-7) measured value of friction forces between samples (2) and track (1). Rotation sensor (9) recorded track (1) rotations. During tests the temperature near the samples was also recorded. More accurate description of the construction and the operation of the tests stand were presented in the papers [3-4, 10]. Such construction of the test stand allowed the study of dry solid friction, boundary friction, mixed friction and wearing of the surfaces in time.

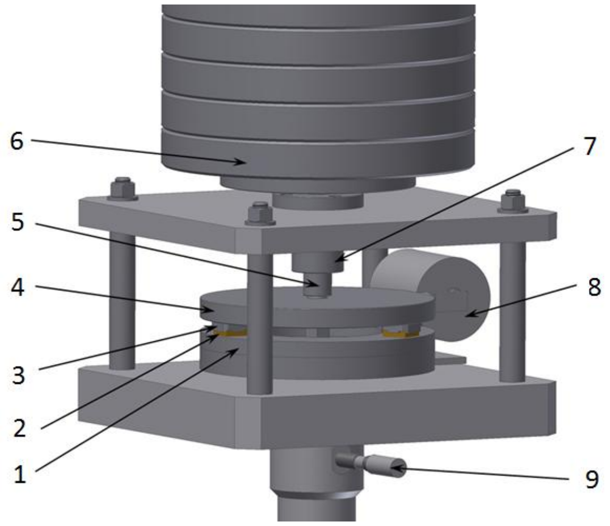

Fig.1: *The schematic of the stand for tribological properties measurement [3-4, 10]*

To determine the effect of the addition of graphene nanoflakes on tribological properties of the grease tests were performed for lithium Shell S2V 100 2 grease without graphene nanoflakes and with its admixture of 0,5%, 2% and 5%. The research was conducted with the aim of equipment works in intermittent cycle. The carried out tests had a duration of 30 minutes. The weight used during tests was 66,7 kg, which resulted in stress level of 6,53 MPa between surfaces of friction pairs.

3. Results

The results of the tests are summarized in diagrams fig.2-3. Fig.2 presents characteristics of the friction coefficient in function of distance, while the temperature recorded during tests are presented in fig. 3 (also in function of distance).

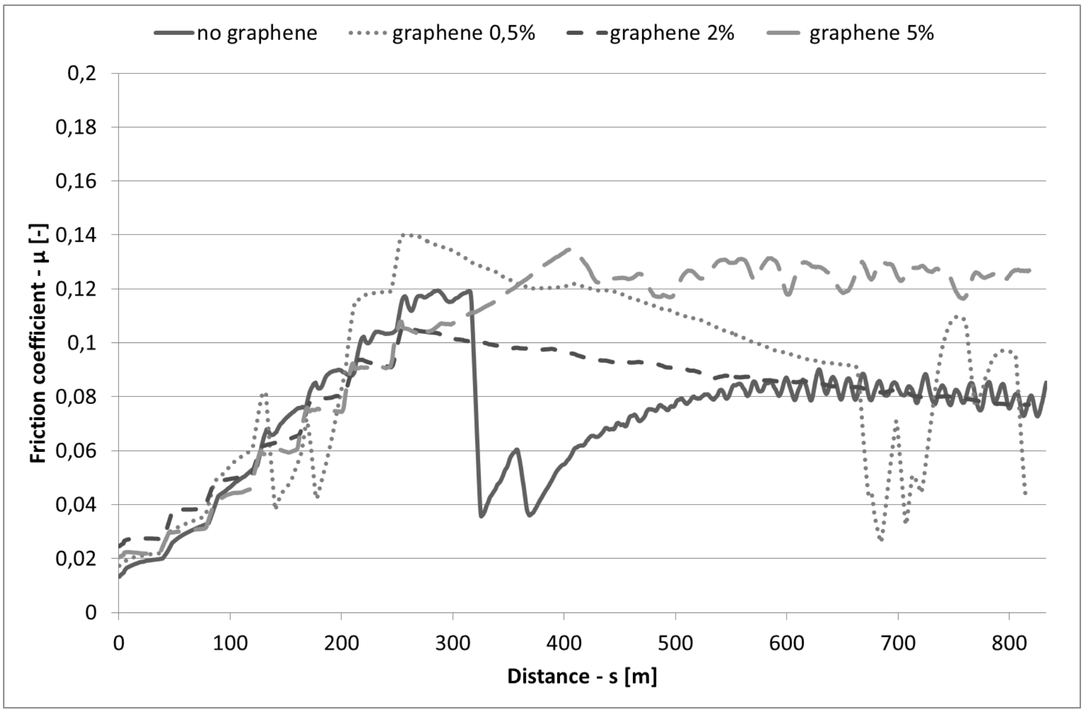

Fig.2: *Diagrams of coefficients of friction μ versus distance s*

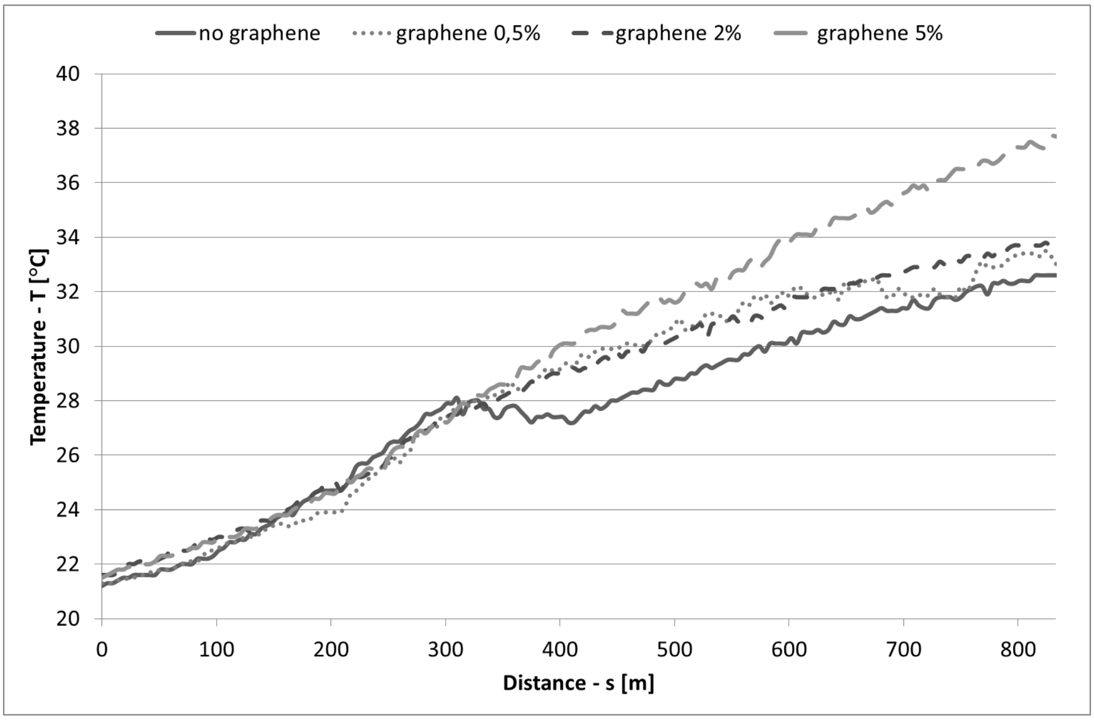

Fig.3: *Diagrams of temperature T versus distance s*

In the first phase of testing (until approx.. 250-300 m) a gradual increase (similar for each type of grease) in value of friction coefficient was observed. The temperature was rising as well. After the first phase, the results for each type of grease start to differ. The non-graphene grease noted a rapid decrease of the friction coefficient, then to gradually rise to a value of 0,08. The 2% graphene grease noted progressive decrease in the coefficient to the value similar to non-graphene one. In the case of higher graphene content (5%) grease the value of the friction coefficient after stabilisation remained at a higher level of 0,12, along with it the temperature increase was faster. When the studied grease contained a small (0,5%) content of graphene, the value of the friction coefficient in time was very unstable. During 30-minute tests an constant increase in temperature was observed. There was no temperature stability, which indicated that the state of balance between generated and removing hear was not achieved. It also means, that the stability of the values of friction coefficient may have a temporary character.

4. Conclusion

Obtained results indicate, that in case of a short-term interrupted (250-300 metres interval, which correspond to the time of approx. 8 minutes) work of the device, the doping of examined grease does not involve a change of its tribological properties. A little longer work time allows to observe divergence of the results in relationship with the degree of doping the grease with graphene. Especially adverse results were obtained for the grease with 5% graphene flake doping, in this case the value of friction coefficient stabilised at 0,12 as opposed to 0,08 for other analysed greases. In the case of a slight degree of graphene doping of 0,5% various changes of the friction coefficient was observed. This indicates, that the properties of that type of grease are unstable.

The most beneficial results were obtained for the non-graphene and 2% doped grease. This indicates that there is no reason to use graphene doping of grease in the examined case (discontinuous work). There is however an worth noting increase in the properties stability for the 2% graphene doped grease in comparison to the non-graphene grease.

The high thermal conductivity of the graphene flakes can still positively affect the properties of the grease in the case of continuous work of a device. Better heat removal from the area of friction may result in its lower rate of wearing away and the preservation of optimal grease properties in an extended period of time. Further research, with the purpose of verifying the influence of the graphene doping on the rate of wearing away of the surface and tribological properties in continuous work conditions, are planned. Obtained results indicate, that the beneficial value of graphene flake doping is 2%, which makes an important information in the context of further research.

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