EXPERIMENT PERFORMANCE TESTING OF A TRIBOLOGY LUBRICANTS ADDING NANOPARTICLESWITH COBALT CHROMIUM WITH COATING STEEL- BALL

Guru prashanth S,
Mr. S. ESWARAN. M.E & Mr. M. MANIKANDAN, M.E., Ph.D.,

ABSTRACT

To improve the oil-solubility of nanoparticles, a new technology was used to prepare a kind of lubricant containing titanium dioxide (TiO2) nanoparticles. The microstructures of the prepared nanoparticles were characterized via transmission electron microscope (TEM) and infrared spectroscopy (IR). Tribological properties of TiO2 nanoparticles used as an additive in base oil were evaluated using four-ball tribometer and ball-on-disk tribometer. In addition, the worn surface of the steel ball was investigated via polarized microscopy (PM) and X-ray photoelectron spectroscopy (XPS). The TiO2 nanoparticles can be completely well-dispersed in the base oil under a new process (NP), which has no significantly negative effect on the anti-oxidation property. The results of the tribological tests show that TiO2 nanoparticles under the NP show a better anti- wear property and friction-reducing property in base oil compared to TiO2 nanoparticles under the tradition process (TP). The main aim of this paper lies in solving with the oil-solubility problem through the combination effect of surface modification and special blend process of lubricating oil. This method was first used to prepare lubricant containing TiO2 nanoparticles and then used as additives in engine oil, gear oil, and other industrial lubricants. At the same time,tribological properties of TiO2 nanoparticles in base oil as a lubricating additivewere also studied.

INTRODUCTION

Conventional lubricant additives are generally those compounds containing sulfur, phosphor, or chlorine, among others [1–3] that play an important role in gear lubrication and cutting lubrication. However, the commercial applications of these kinds of additives are unsatisfactory because of the pungent odor, extreme corrosion, and the poor thermal stability [4–7]. Therefore, it is necessary to develop new kinds of additives that can be used as a substitute for traditional lubricant additives. The use of nanoparticles as oil additives and lubricants is a recent idea. Numerous nanoparticles have been investigated in recent years [8–22]. These oil additives contain small particles ofsolid material, and their use is not straightforward and only recently has been recognized as feasible. The utilization of oil additives as nano lubricants presentsmany advantages, as they are relatively insensitive to temperature, and tribo chemical reactions are limited, compared to traditional additives. Differentiate- friction and anti-wear mechanisms using the nanoparticulate additives have been explained in previous papers

Experimental results with nanoparticles used as additives in oil lubricants show that they deposition the friction surfaces and improve the tribological properties of the base oil, displaying good friction and wear reduction features, even at low concentrations. Inter alia, titanium dioxide (TiO_2) nanoparticles as lubricant additive were studied with much more attention, because of their good performance on anti-oxidant features, relatively low toxicity, pleasant odor, and non-volatility [25–27]. Unfortunately, nanoparticles are not well dispersed in nonpolar organic solvents due to their oleo-philicproperty, which limits the nanoparticles applications in lubricants. Now, two approaches to solve this frequently problem are taken. The first method is the addition of dispersant into base oil. The main drawback of this method is that the sedimentation is unavoidable after a long-time storage and the negative effect of same dispersants on tribological properties [28–31]. The second method is the usage of surfactant [31–33].

2. EXPERIMENTAL ARRANGEMENTMECHANISM OF LUBRICANTS

All the surfaces in nature are rough, at least microscopically (or even at atomic level). When two rough surfaces slide against each other (or roll) the asperities of the surfaces come close to each other and interlock, adhere and generate friction. The goal of any lubrication approach is to separate the rubbing surfaces by a lubricant layer, which prevents (oralist minimizes) direct contact of the bodies.

Fluid Property	Industrial Gear Oil	Hydraulic Fluid	Turbine Oil	Engine Oil	Compressor Oil	Automotive Gear Oil
Air Release	•	•	•	• (red)	•	•
Foam Stability	•	•	•	• (red)	•	•
Demulsibility	•	•	•		•	•
Oxidation Stability	•	•	•	•	•	•
Thermal Stability	•	•	•	•	•	•
Extreme Pressure	•					•
Lubricity (AW)	• (red)	•		•	•	•
Rust Protection	•	•	•	•		• (red)
Dielectric Strength		• (red)	• (red)			
Biodegradability		• (blue)			• (blue)	
Bulk Modulus		•			•	
Filterability	• (red)	•	•	• (red)	• (red)	
Shear Stability		•		•	•	• (red)
Hydrolytic Stability	• (red)	•	•		• (red)	• (red)
Dispersancy				•		

• Very Important • (red) Somewhat Important • (blue) Application dependent

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2.2 . Impact of nanoparticles chemical composition on the performance oflube oil

Types	Nanoparticles
Metals	Ag, Bi, Co, Cu, Fe, Ni, Pd, Sn
Metal oxide	Al_2O_3, CuO, Fe_3O_4, TiO_2, ZnO, ZrO_2
Carbon and its derivatives	Graphene, Diamond, SWCNT, MWNTs
Sulfides	WS_2, MoS_2, CuS
Rare earth compounds	LaF_3, CeO_2
Nanocomposites	Al_2O_3/SiO_2, Al_2O_3/TiO_2, Cu/graphene oxide, WS_2/MoS_2
Others	SiO_2, PTFE, BN, Serpentine

Energy losses due to friction are incredibly high. Energy losses in the engine due to friction result in heating and promote the wear on the surfaces of movingpart. It has been reported that 75–82% total energy losses in the vehicle, enginelosses is between 68% and 72%, 12–30% energy from fuel used to move the vehicle and energy losses due to friction are around 3%, as shown in Figure 1 The combined effect of friction and wear caused 30% total energy losses [22]. Energy losses due to the friction can be reduced by a few technologies such as the design of tires and bearings, tribology, and additives. Further, in order to overcome the energy losses, the lubricant which imparts the best lubrication is essential. Processes 2020, 8, x FOR PEER REVIEW 3 of 33 and additives.

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2.3.1 TRIBOLOGY

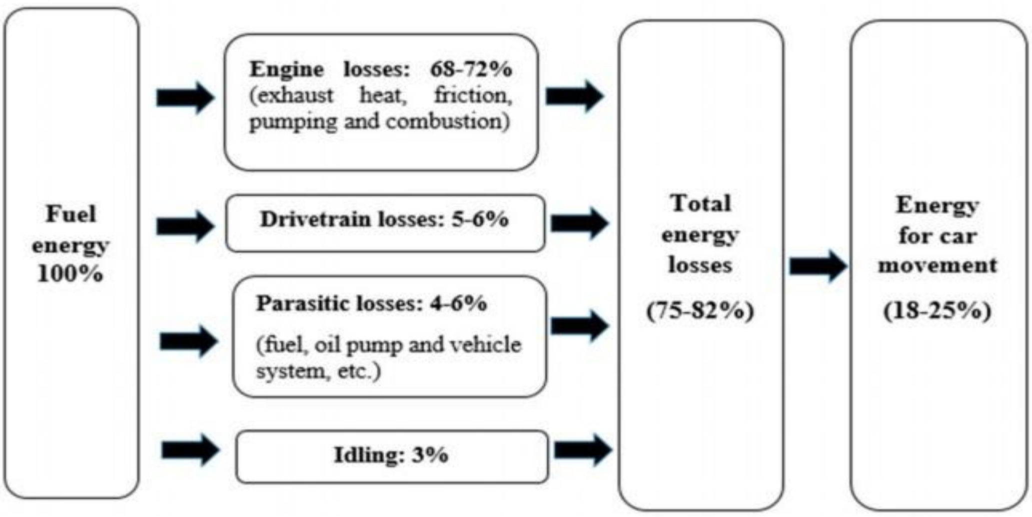

FIGURE 1.1 TRIBOLOGY

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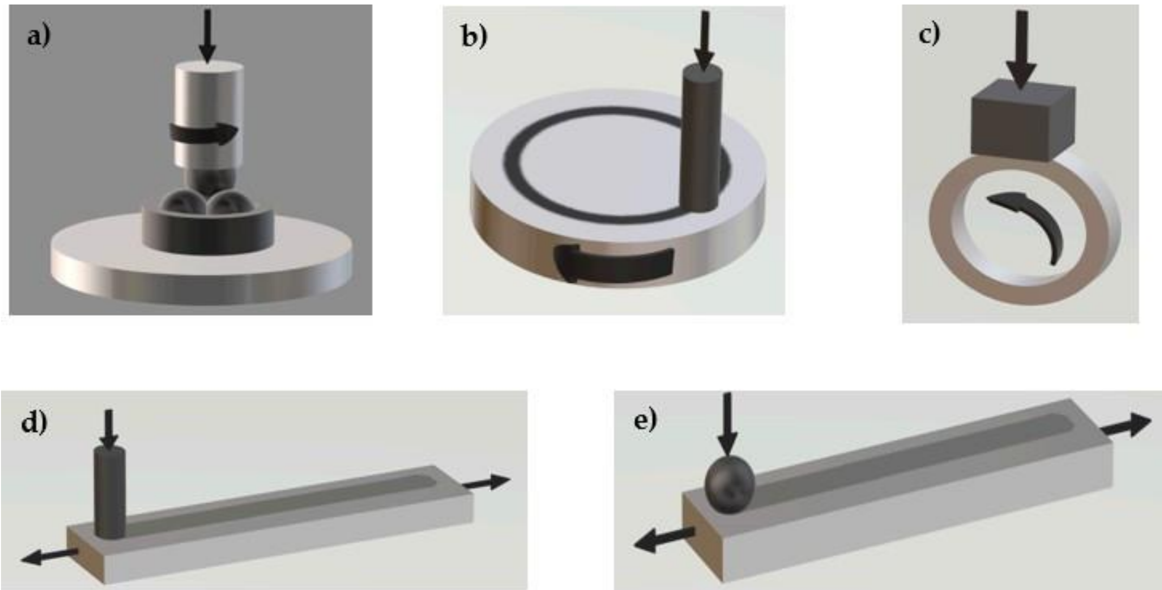
Tribology is the study of the science of interacting surfaces or two moving bodies in relative motion. It is related to friction, wear, lubrication, degradation of metal surfaces, corrosion, engine life, and energy losses. Since there are incredibly high energy losses due to this phenomenon, such losses caused by friction and wear should be minimized [16]. To satisfy the lubricationrequirements of the particular application, specifically in tribological aspects, the most important way is selecting a suitable lubricant. Lubrication, friction, and wear are related to tribological performance. Lubricity is concerned with the formation of a protective layer or tribunivcial on the contact surfaces. High lubricity reduces direct surface contact, thereby reducing friction and energy losses [17]. However, having a high lubricity is not always accompanied by better wear protection, because the formation of a protective layer on the rubbing surfaces happens through the absorption of the surface-active substanceof lubricants such as base stocks or additives. When surface asperity contacts each other, three types of mechanical wear are possible resulting



in the following: adhesion, abrasion, and fatigue [18]. Adhesive wear occurs when high loads, high temperature, or inadequate lubrication cause two relatively moving surfaces asperity welds and then immediately tear apart. Abrasive wear happens when surface rubbing occurs between contact surfaces of relative hardness. Fatigue wear is the progressive and localized structural damage of material in repeated loading [19]. Prior to discussing the tribological performance of the nano lubricants, it is necessary to understand the three basic tribology parameters, which are the mechanical properties of a tribological system, lubrication, and the physicochemical properties of the lubricant

3.0 Future scope

At the time of analysis, it is observed that the performance parameters changeby 10%–15% upon small (in mg)
changes of the nanoparticles. The performance of the lube oil in two consecutive additions of nanoparticles is unknown. Therefore, there is a need todevelop a method to characterize the performance parameter of nano
lubricants between two successive additions.
Various researchers have well covered the composition of nanoparticles. It hasshown their performance well under multiple conditions and materials. The compatibility of nanoparticles
with surface material remains untouched so far. This is a critical research gap for future research in the Fifieldof nano lubrication. Medium-sized segments (31–60 nm) of nanoparticles may be part of future studies because this section can improve the characteristics of the oil. The authors use a fixed number to represent the size, which means all the nanoparticles' dimensions. Researchers can also focus on the size range. Asis known, small-sized nanoparticles can efficiently provide rectification effects,and large-sized nanoparticles can easily show rolling effects. So, the combination of both can improve the quality of nano lubricants, which will be the subject of future studies.

Studies about multiple-shaped comparisons are lagging. It may perform unfavorably, but its analysis should be needed in the future. Take an example ofa nanotube and a spherical-shaped particle. Spherical shapes of nanoparticles can help reduce COF and improve nanotube wear.

4. Conclusions

The analysis shows that the literature concerning the potential of nanoparticles to improve lubrication performance is still active. Evidence is available where the nanoparticles' chemical composition, size, and shape are
essential in lubricating oil performance. Nanoparticles having multiple chemicalcompositions, sizes and shapes have been evaluated under different environmental conditions with various base oils. And there is no doubt that nanoparticles have led to extraordinary improvements in the efficiency of lubricants. It can be said with confidence that many nanoparticles have also been evaluated for their effectiveness. Still, now a significant
concentration is on environmentally friendly lubricants. Also, the areasmentioned in the future scope are subjects of attention.
Some more conclusions from this review of the literature are listed here.

- The performance of sulfatide nanoparticles is awe-inspiring in terms ofperformance characteristics.

- Basic information about nanoparticle size, shape, base oil, and surfactant ordispenser provides a clear picture of nano lubricants.

- Performance of Size <30 nm The performance of nanoparticles is astonishing.

- Nanoparticles such as spherical and globular play exceptionally well inlubricating oil performance.

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5.0 DATA AVAILABILITY STATEMENT

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