ABSTRACT

Innovations in technology are placing continuous demands on materials for better and better performance and hence researchers are focusing the efforts for performance enhancement of existing materials by various techniques. Lubricating oils are the focus of research attention in this aspect since further reduction in friction and wear properties of oils would lead to further saving of tribo-materials and energy apart from improving their efficiency. Remarkable tribo-performance enhancement is reported in the literature due to addition of particles of solid lubricants in lubricating oils; especially that of nano-sizes. In spite of the well-known fact that the particles of hexagonal boron nitride (hBN), graphite, Polytetrafluoroethylene (PTFE) etc. are proven as very efficient solid lubricants for composites; no in depth efforts are reported on investigating their full potential as anti-wear (AWA) and extreme-pressure (EPA) additives in oils, especially in comparative manner. The influence of size of particles on performance enhancement, keeping all other conditions same, has also not been studied so well. The in-depth tribo-investigations on the efficiency of nano-particles (NPs) are also scanty and call for immediate research attention.

In the present work, particles of three solid lubricants; hBN, graphite and PTFE were selected for comparative exploration of their tribo-potential. The major aim was to explore their comparative tribo-potential in oil as AWA and EPA. It was hence decided to develop oils based on these additives with different particle sizes keeping % of particles always fixed (4 wt. %). The other research themes were; influence of varying size of NPs and influence of dispersant (its type and amount) on tribo-performance apart from physical properties such as density, viscosity, viscosity index, flash point and stability of suspensions as a function of time. The efforts were also focused to optimize the amount of NPs for best performance and also combination of particles for possible synergistic effect. The tribo-performance evaluation was done on 4 ball tester as per ASTM D4172 and IP 239 standards. Various characterization
techniques such as SEM (scanning electron microscopy), EDAX (energy dispersive X-ray analysis), AFM (atomic force microscope), XPS (X-ray photoelectron spectroscopy) and MRS (micro-Raman spectroscopy) were explored for worn surface analysis to understand the wear mechanisms. The inclusion of particles, especially NPs proved very much beneficial in case of hBN and graphite. The NPs of PTFE proved less beneficial because of the non-spherical shape. PIBSI (polyisobutylene succinimide) in 1 wt. % concentration proved to be most efficient amongst selected four dispersants. The research work was finally summarized by reporting the significant achievements in improvement in EP and AW properties of selected oil (Group III). It was concluded that as EPA, PTFE particles of 12 microns and sub-microns (100-150 nm) proved best since 344 % improvement as compared to base oil was observed. Graphite particles ranked as second one (78%) improvement while hBN proved poorest (27 %). As AWA, the difference in these three types of particles was not significant although performance order was PTFE ≈ hBN > graphite. Interestingly combination of particles of hBN and PTFE in certain ratios showed synergism in AW and EP performance. Finally the work could make some decisive recommendations for selecting proper type, size, amount and combination of particles in right kind of dispersant for optimizing the tribo-performance (EP and AW) along with adequately long stability of suspensions.