TRIBOLOGICAL INVESTIGATIONS OF NANOLUBRICANTS FOR MACHINE TOOL SLIDEWAYS

ABSTRACT

Nanotechnology is a revolutionary concept introduced in the 21st century that has the potential to improve the characteristics of materials in many fields. In recent years, nano-sized materials have emerged as a new additive alternative for lubricants because nanomaterial possess many special properties, such as the quantum-size effect, the small size effect, and surface and interface effects; the application of nanoparticles in tribology has received considerable attention.

The machine tool slideways are required to start quickly and then move at a constant velocity. They experience high loads and operate at low velocities. In slideways, usually boundary lubrication occurs. All these factors lead to stick-slip phenomenon, which is undesirable. Hence, the lubricant applied should be capable of reducing the stick-slip friction.

In this research work, different nanolubricants are investigated specifically to apply in lathe slideways to reduce friction and wear. Based on the literature review, suitable nanoparticles and base oils were selected for the preparation of nanolubricants. The tribological characteristics of nanolubricants were evaluated and the results were compared with ISO VG 32 oil; a conventional lubricant used in machine tool slideways. The influence of nanolubricants in controlling stick-slip friction in lathe slideways was also studied.

Molybdenum disulphide (MoS_2) nanoparticles were synthesized using a planetary ball mill apparatus and the nanolubricants were prepared by adding various

proportions of MoS_2 nanoparticles in Polyalphaolefin (PAO) base oil. Friction, wear, and stick-slip characteristics of the nanolubricants were assessed using pin-on-block Reciprocating Friction Monitor (RFM). Extreme Pressure (EP) properties of the lubricants were determined using a Four Ball tester. Fromall tribological test results,it is found that the addition of MoS_2 nanoparticles in PAO base oil results in approximately 20% reduction in Coefficient of Friction (COF) and 30% improvement in EP load carrying capacity, compared to that of conventional ISO VG 32 oil. The mechanism behind the improvement in tribological behaviour of MoS_2 based nanolubricant is most likely the formation of a thin, MoS_2tribofilm at the wear surface.

MoS_2+Graphite based nanolubricants were developed and its tribological characteristics were investigated using RFM and Four Ball tester. Field tests were conducted using a lathe. Based on friction, wearand EP test results, it is provedthat the MoS_2+Graphite based nanolubricantsshowed around 55% friction reduction,41% wear reduction and 41% higher load wear index than that of ISO VG 32 oil. Also the weld load of MoS_2+Graphite based nanolubricant compositions is 58.7% higher compared to ISO VG 32 oil. Field test results proved that the quality of surface finish of machining is improved by using nanolubricant. Field test-vibration analysis results showed that the nanolubricant reduces the vibration level in lathe carriage. Overall, field test results proved that the nanolubricant reduces the stick-slip friction in lathe slideways. This improvement is due the formation of thin tribo film between the contacting surfaces.

The depletion of conventional energy sources and the need to reduce environmental emissions have urged researchers to investigate green or renewable energy alternatives. Inthis regard, oil from agricultural feedstocks is a suitable substitute for petroleum lubricants because vegetable based lubricants presents biodegradability, nontoxicity, and easy disposal. The biodegradable nanolubricants were prepared by adding 0.1% wt of Copper oxide (CuO) nanoparticles. Friction and stick-slip characteristics of the nanolubricants were assessed using pin-on-block reciprocating friction monitor. Extreme pressure properties of the lubricants were evaluated using a four ball tester. Friction test results showed that the addition of CuO nanoparticles in biodegradable oils improve antifriction and antiwear properties. Sesame nanolubricant showed the least coefficient of friction (45% reduction) compared to ISO VG 32 oil. Soybean nanolubricant showed 40% reduction in friction at high temperature. Extreme pressure test results showed that all bio-nanolubricants have higher Load-wear index than ISO VG 32 oil. All bio-nanolubricants showed 21% higher weld load compared to ISO VG 32 oil. The antifriction mechanism could be the formation of tribofilm through deposition of CuO nanoparticles on interacting surfaces, which decreases the shearing resistance, thus improving the tribological properties. Field testing in lathe also proved that the biodegradable nanolubricants effectively reduce the stick-slip friction in lathe slideways better than the ISO VG 32 oil.