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Influence of nano particles of ZnO as additive in rapessed oil for evaluationg the tribological behavior

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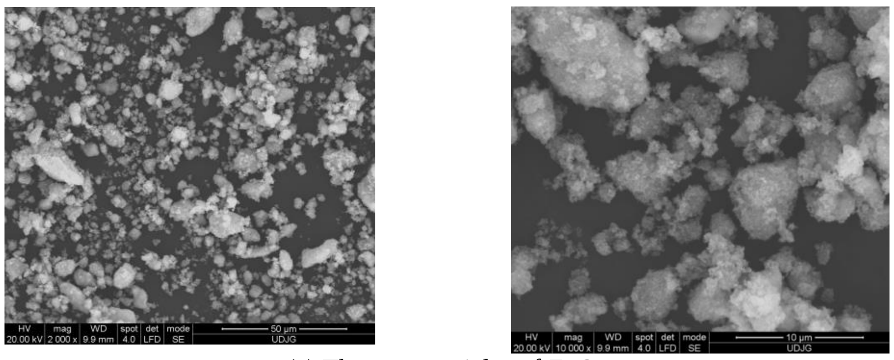
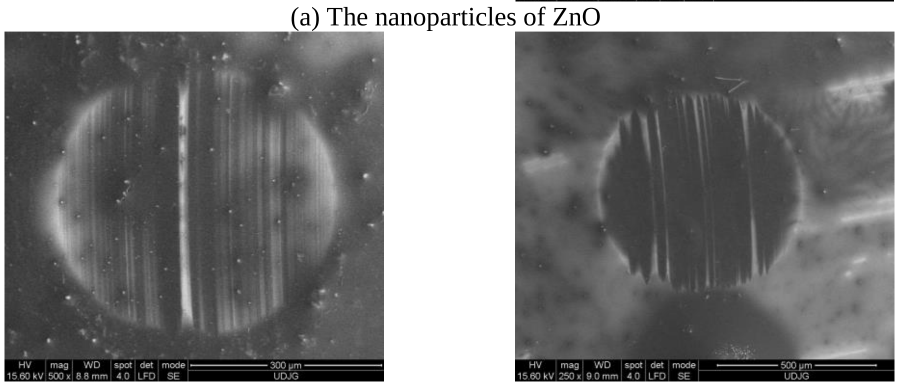
Vegetal oils consist of triglycerides influencing their performance, as poor thermal, hydrolytic and oxidation stability, but also low viscosity. Most vegetal oils cannot withstand reservoir temperatures greater than 80ºC. Additivation of this oil is still at the beginning as, due to their complex composition, the additive response could be unexpected. Metallic oxide are treated in literature [1], [2] as a particular group, including ZnO, CuO, Al_2O_3, ZrO_2, TiO_2.

This paper presents results of testing the coarse rapeseed oil additivated with different concentrations of ZnO (0.25%wt, 0.50%wt and 1%wt). Tests are done on a four-ball machine from the laboratory LubriTest, at “Dunarea de Jos” University of Galati. The test parameters were load on the main shaft of the machine: 100 N, 200 N and 300 N and the rotational speed 1000 rpm, 1400 rpm and 1800 rpm. Particles of ZnO (Fig. 1a) have 14±5 nm [3]. The test parameters were selected for mild regime: load on the main shaft of the machine: 100 N ... 300 N and the sliding speed of 0.38 m/s, 0.53 m/s and 0.69 m/s, test duration 1 h.



(a) The nanoparticles of ZnO



100 N 300 N

(b) 1% ZnO, 0.69 m/s

Fig. 1.

From SEM investigations, the nanoparticles of ZnO are spread over the contact scar of the ball. Images in Figure 1b were obtained at a scanning electron microscope, after drying the balls as they were taken from their cup to point out the presence of the additive on the contact zone. The additive does not form a continuous layer on the contact and the nanoparticles agglomerate in very different size and shape, especially under low load (F=100 N). Under higher load, the particles agglomerate less and have a spheroidal shape.

For the tested range of ZnO concentration, the value of 1% wt does not improve the friction coefficient, but the wear rate of WSD was lower than that obtained with the base oil and the values are less sensitive with load and sliding speed for the more severe regimes when the this base oil is additivated

The qualitative modification could be allocated to change in functioning regime. For instance, at v=0.38 m/s, COF has the lowest values (blue color) for the neat oil till 200 N and for 0.75...1% additive concentration, for F=100...150 N. At highest speed (v=0.69 m/s), COF has only a small region (F,c) with values around 0.1, meaning the speed increase is beneficial for not losing power by friction (Figure 2).

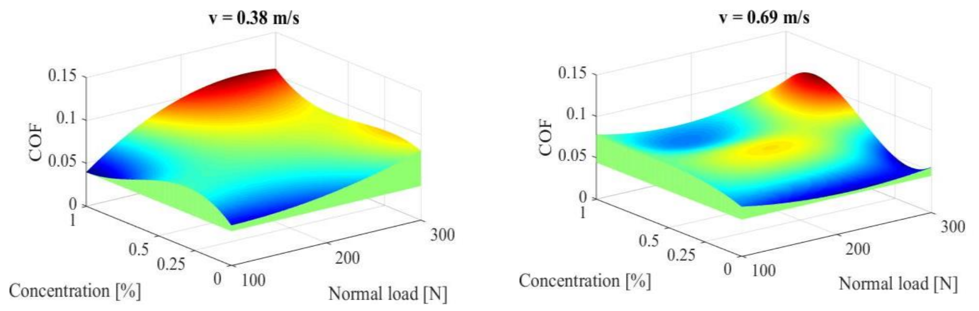


Fig. 2. The maps for the friction coefficient (COF)

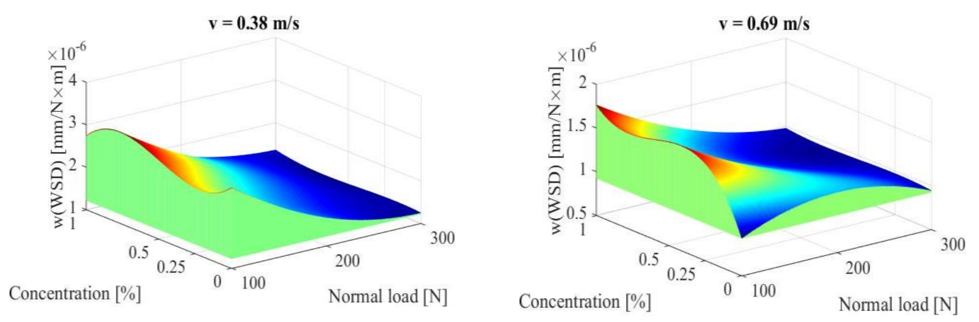


Fig. 3. The maps for wear rate of WSD

When analysing the wear parameter, two distinct zones are visible on the maps, one of high values (red and yellow colors), characteristic for low load and the other one, with low values (light to dark blue) for F=200...300 N, less dependent on additive concentration. Speed makes the wear rate of wear scar diameter to be under 1×10^{-6} mm/N×m, a good value as comparing to other results obtained on four-ball tribotester. Higher speed produces a fluid film that is in the favor of reducing wear by keeping the separation of the solid bodies in contact (Figure 3).

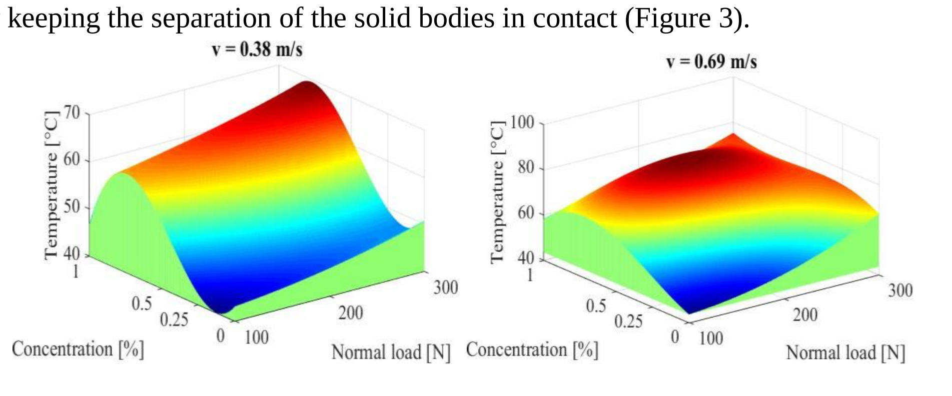


Fig. 4. Temperature maps as a function of additive concentration and load

Observing the evolution of end test temperature (Fig. 4) for the neat rapeseed oil, the lowest values were obtained and the increase of final temperature to load is almost linear. For F=300 N and v=0.38...0.53 m/s, the temperature has just a little increase of several degrees, but for v=0.69 m/s, this increase is of 10...14 °C. For the additivated lubricant, the maximum final temperature was obtained for the additive concentration of 0.5...0.8%.

References

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