Wear Monitoring of the Trucks

Vladimír Hönig
Faculty of Agrobiology, Food and Natural Resources, Department of Chemistry, Czech University of Life Sciences Prague, Kamýcká 129, 165 21, Prague 6 - Suchdol, Czech Republic
E-mail: honig@af.czu.cz

The article deals with the monitoring of wear of truck oils in order to determine their wear. The research part is focused on engine oils, tribology and analytical methods for evaluation of oil degradation by abrasion particles. Thanks to these non-invasive technologies for monitoring and analyzing engine wear trends, an optimum oil change interval can be effectively set. The experiment analyzes engine oil samples from trucks and found the values of metal particles. Reference values for oil degradation levels are determined based on trend analysis. Metal abrasion particles and total impurities are determined and the state of the oils is evaluated experimentally.
Optimal oil exchange iterval must be adjusted based on experiments. Wear of the truck engines is very individual with respect to the service life of the oil. The shortening of the interval is suggested with respect to the evaluation of the experiment. The aim of the article is to minimize the negative effects of abrasion during truck operation.

Keywords: Diagnostics, Abrasive Particles, Adhesive Particles, Wear Particles, Discriminant Analysis

1 Introduction

Engine oil is a very important part of the engine. Claims for oil performance are very high. Compared to most components, engine oil is easily replaceable between elements. Oil monitoring can extend the engine's life and economy.

Engine oil is degraded during operation and also during its inactivity. The influence on engine oil quality has several factors: mechanical inpurities, high temperatures, fuel penetration and others. If the engine oil parameter limits are exceeded, the oil is unsuitable and should be replaced. Engine oil must be continuously removed from all solid and liquid impurities. [1,2]

Metal particles are formed by friction of two metal surfaces even in the case of high quality lubrication. Wear particles can have a size up to the thickness of the lubricating film and together with other mechanical impurities initiate an increase in friction and wear levels. High quality oil filter filters remove particles from the oil just above about 10 microns. The engine and all friction surfaces are made of metallic materials. The basic element is iron refined by the addition of other metals. The goal is to increase surface hardness or improve sliding properties. [3]

Ideally, the friction space of the surface is separated by a layer of oil and thus does not come into contact with each other.

Based on the amount of specific metal in the oil, it is possible to estimate the potential location where the fault occurs. It is necessary to be interested in other metals such as aluminum, copper, chromium, lead, tin, nickel, and silver. Other metals such as zinc, molybdenum, antimony, magnesium, which are mostly derived from oil additives, can be found in the oil. However, a certain level of metal-in-oil concentration is quite normal and optimal. Manufacturers specify metal concentration limits that the oil should not exceed. Other mechanical impurity in engine oil is carbon. Carbon is product of incomplete combustion of gasoline or diesel engines. For diesel engines, the carbon concentration is higher. A reduction effort is one of the factors behind the introduction of EURO emission limits. [5,6]

The practical aim of tribotechnical diagnostics and tribology is to minimize the main disadvantages of rigid surfaces under contact (friction, wear). Most machine failures or outages are related to the interaction of moving parts such as bearings, sprockets, cams [7]

Tribotechnical diagnostics is one of methods of technical diagnostics using lubricants as media for obtaining information. Exploited oil is the carrier of a multidimensional diagnostic signal. The aim of tribotechnical diagnostics is to identify, evaluate and report the presence of foreign substances in the lubricant in terms of quantitative and qualitative point of view [8]

The friction force consists of the sum of four parts, which are the sum of the individual components (1).

$$F_t = \Sigma F_1 + \Sigma F_2 + \Sigma F_3 + \Sigma F_4 \quad (1)$$

ΣF_1 – resistance of elastic deformation [N] ΣF_3 – resistance of material scoring [N]

ΣF_2 – resistance of plastic deformation [N] ΣF_4 – resistance to sealing of the adhesive joint [N]

2 Materials and methods

The reason for analyzes is to optimize oil change of trucks according to real state. Oil samples of 3 MAN TGX trucks have been sampled. Sampling was conducted from October 2015 to January 2018.

MAN 1*a* –the sample was taken after 8,000 km; 27,000 km; 50,000 km; 65,000 km; 85,000 km
MAN 2*a*– the sample was taken after 9,000 km; 30,000 km; 55,000 km; 70,000 km; 80,000 km
MAN3 – the sample was taken after 8,000 km; 28,000 km; 60,000 km; 80,000 km; 90,000 km
MAN1*b* – the sample was taken after 8,000 km; 29,000 km; 52,000 km; 79,000 km; 91,000 km
MAN2*b* – the sample was taken after 7,500 km; 31,000 km; 53,000 km; 75,000 km; 86,000 km

The prescribed oil change interval by manufacturer for all samples and vehicles according to the ProFit-Check III maintenance list is 100,000 km. Two oil change intervals for vehicle MAN1 and MAN2 were analyzed – the interval *b* follows the interval *a*. Replenishment of oil does not exceed 5 liters of all truks and does not affect the results.

These methods were chosen:

- determination of impurities by Thin Layer Chromatography (*TLC*). The method measures the degree of dimming of the central zone of drop test. The test is carried out by applying a drop of oil to the chromatographic paper or Silufol – foil. The basis of the method is the creation of distribution circular zones due to the different kinetics of oil components. A professional scanner from Canon Cano-Scan 9950F and Photoshop version 8was used to digitize the obtained oilograms and to measure the opacity (degree of darkening) of the central oilogram zone.
- analysis of metal abrasion particles by ferrographical analysator SpectroT2FM Q500.

Fig. 1 *Main components of SpectroT2FM Q500*

Main components of the ferrography analysator (Fig.1):

- model T2FM Analytical Ferrograph ;
- bichromatic microscope;
- video camera;
- video capture card;
- image capture software;
- optional industrial standard PC.

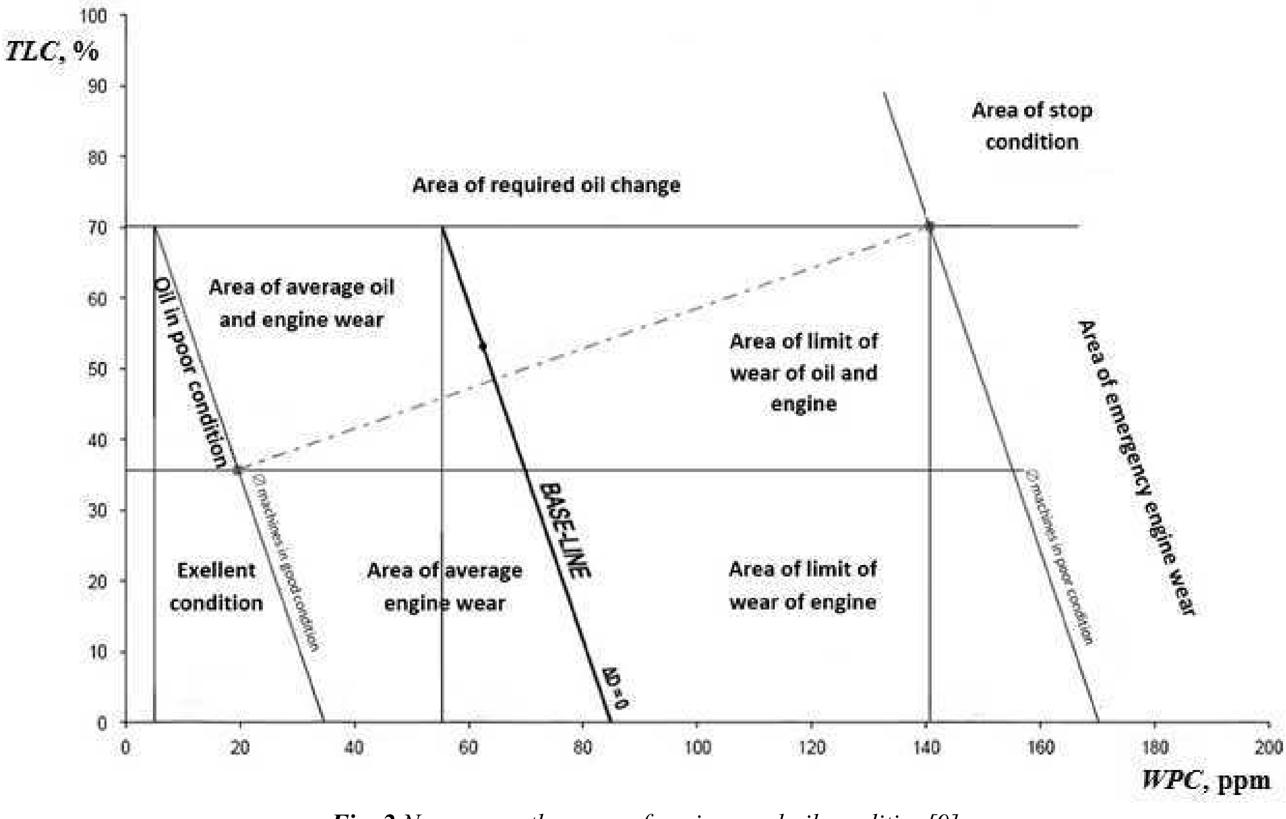

Fig. 2 *Nomogram the wear of engines and oil condition[9]*

The evaluation of the test results was done by comparison method of multidimensional statistical analysis and by a nomogram the wear of the engine. Discrimination analysis as a multidimensional statistical-analytical analysis for sample evaluation has been used. The analysis serves to interpret data obtained not only on the basis of a typical "oil" analysis, but also to interpret a series of other real-time data. Discrimination analysis also serves as a classification process (Fig.2). The nomogram shows the dependence of wear particles in oil on the degree of oil darkening from *TLC*. Horizontal axis *x* shows wear level absolute amount of particles (*AAP*) in 1.ml^{-1} and main vertical axis *y* is showing opacity of central zone *TLC* in %. "Centroid of all values *B*" (Fig. 2 and 6) is calculated by calculating the arithmetic mean of all values. This point divides the whole group into two sets of points: "good" and "bad". From the remaining values of both sets is calculate the arithmetic averages of the so-called "Centroid of good machines *A*" and "Centroid of bad machines *C*". The basic line of BASE-LINE is perpendicular to the trend line of points *A*, *B* and *C*. Next, we create parallels with the *x*-axis passing through the *A* value and the *C* value. The final step in the graphical processing of the nomogram is the construction of the parallel with the BASE-LINE passing through points *A* and *C*.

The graph shows the distribution of values to individual zones for practical purposes (Fig.2):

- excellent condition;
- area of average oil and engine wear;
- oil in poor condition;
- area of required oil change;
- area of emergency engine wear.
- area of average engine wear;
- area of limit of wear of engine;
- area of stop condition;
- area of limit of wear of oil and engine [9].

3 Results

Figure 3 shows the absolute number of particles in the 1 ml oil sample *AAP*, which were counted by the device depending on the vehicle's mileage.

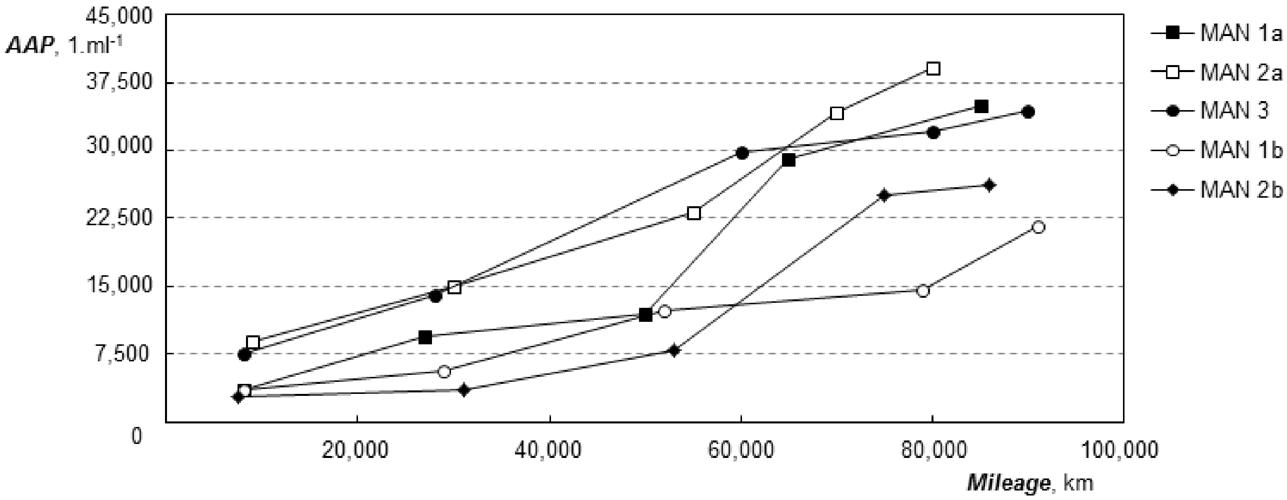

Fig.3 *Dependence of the absolut amount of particles on mileage*

The MAN 2b vehicle has the lowest particle amount. Good oil filter function and quiet driving style are important and can be seen on the MAN 2b.

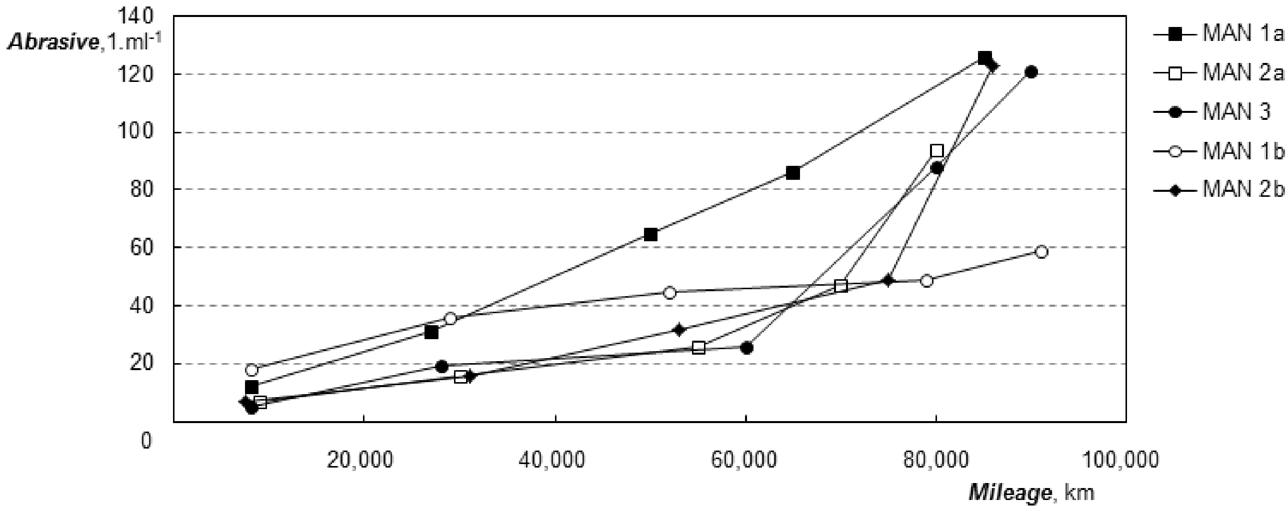

Fig. 4 *Dependence of the abrasive particles on mileage*

Figure 4 shows the dependence of abrasive particles on the run. The correlation between Figures 3 and 1 can be seen in both MAN 1b and MAN 2b. Overall, the wear trend is low and indicates the correct oil filter functionality, good engine performance and efficient use.

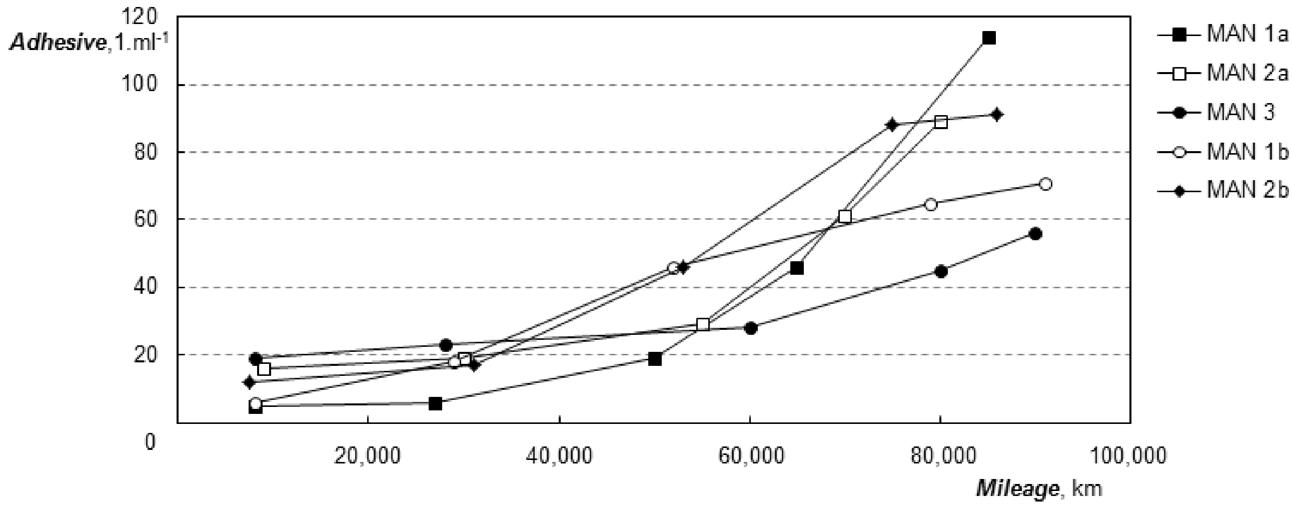

Fig. 5 *Dependence of the adhesive particles on mileage*

The correlation between the samples in Figures 4 and 5 can be seen. Correlation between particles means good truck status. Large differences between values would mean poor vehicle running-in or emergency.

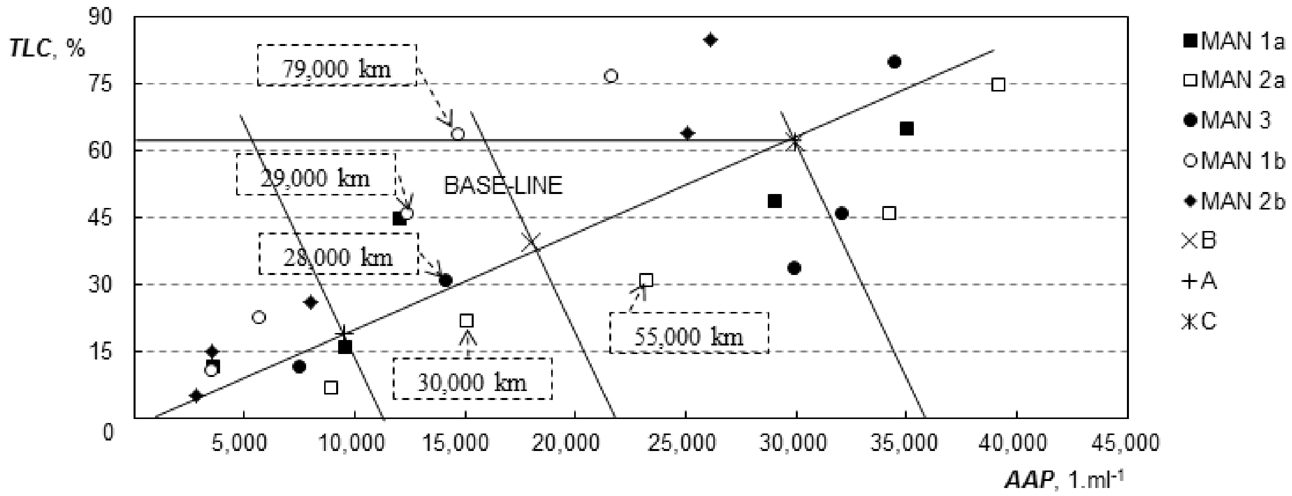

Fig. 6 *Nomogram the wear of the trucks*

The measured values from the analyzed oil samples are presented in the nomogram in Figure 6. The nomogram shows the dependence of wear of metallic particles *AAP* on the degree of *TLC* oil darkening. BASE-LINE in Figure 6 shows the optimum oil change interval. Mileages for samples located near BASE-LINE are shown.

Several samples were found in the limit areas and some in the areas of emergency wear. Changing the interval is therefore necessary.

The wear of the oil and the vehicle depends on the type of operation. The nomogram shows that the oil change interval for all vehicles must be shortened. The MAN 2b carries the smallest wear of metallic particles. The machine operator was informed of the effect of the operation and therefore the difference in wear between the intervals *a* and *b* is visible. Estimating the optimal oil change interval without analyzes is not possible and it is therefore necessary to monitor the oil status to minimize the negative effects of abrasion [7,11]

Trucks are in good technical condition with respect to the results in Figures 4 and 5. A large proportion of this has low-weight operations and regular maintenance. The optimum engine oil change interval is an important factor affecting the technical and economic parameters of the truck.

4 Conclusions

The timing of oil change positively affects the economy of the truck and maintains its serviceability. Maintenance of oil filling based on its tribotechnical diagnostics is a complex method that includes monitoring of chemical and physical properties of oil, engine wear and engine maintenance records.

Tribotechnical diagnostics analyzes provide increased reliability and efficiency of maintenance and also deliver considerable savings.

Thanks to these non-invasive technologies for monitoring and analyzing engine wear trends, an optimum oil change interval can be effectively set.

The article shows that there are considerable differences in the quality of truck oil. Differences are due to the type of activity, the weight of the load, the climatic conditions and the operator's skill (gentle handling).

Shortening the maintenance interval would not only prevent higher wear in the last few kilometers before oil change, but also reduce specific fuel consumption. Recommendations for shortening the interval are based on the above results.

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