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DIAGNOSTIC OF TRIBOMECHANICAL SYSTEMS APPLIED ON MOTOR VEHICLES

S. Peric*, A. Grkic** and M. Krsmanovic***

ABSTRACT

The central component of the tribomechanical system is the lubricant, whose most significant function is the lowering of friction and wear appearing in the contact of two surfaces in relative motion. As a subsystem, tribomechanical systems are integrated everywhere into the technical systems. Apart from more significant applications in internal combustion engines, transmission, and hydraulic systems, there is also a large number of further applications. Due to the poor execution of the tribomechanical system or inadequate application, if it is not fit for the given system, commercial losses may occur measured in billions of euros annually. That is why the significance of the tribosystems is not only technical, but also economic and environmental. The concept of the future successful development endeavors to associate economy and ecology into a complex and non-contradictory system.

Diagnostics of tribomechanical systems in motor vehicles is part of the overall process of managing maintenance. It provides an opportunity for the user to predict the damage and/or failure, and thus prevent delay in the work and extend usage life of motor vehicles. Recently, special attention is focused on development of modern devices and methods for monitoring condition changes of tribomehanical characteristics in systems. There are used today different physical and chemical methods and tribology methods for tribomehanical system diagnosis. Experience in technical systems exploitation showed that the most effective failure prognosis is according to parameters, particles created as result of wear, which are reliable indicators of wear. Analysis of oil samples which contain particles, created as results of wear, enable evaluation of system tribology condition in different phases of system exploitation. The paper presents the tribological tests in the analysis of oils that are used for the assessment of this condition. Furthermore the results of experimental research of tribological characteristics engines and power transmitters oil was sampled from engines and power transmitters of vehicles Mercedes, PUCH and PINZGAUER, which were in use. Investigations realized that there is a change of tribological characteristics of oil for lubrication in the engines and power transmitters of vehicle. These changes are in direct dependence on the state of all elements tribomechanical engines and power transmitters system, and depending on their functional characteristics. Finally, is a conclusion based on the realized testing?

KEYWORDS: monitoring, maintenance, tribological characteristics oil, Oil Analysis**.**

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* University of Defence, Military Academy, Belgrade, Serbia, sretenperic@yahoo.com
** University of Defence, Military Academy, Belgrade, Serbia.
*** University of Defence, Military Academy, Belgrade, Serbia.

NOMENCLATURE

b	Width wear.
Fn	Normal force.
Ft	Friction force.
h	Length wear.
Ra	Average arithmetic profile deviation in the length of evaluation.
Rmax	Maximum height profile.
t	Contact time.
T	Oil temperature.
v	Velocity.
v_{kl}	Sliding speed.
δ	Depth wear.
ω	Angular velocity.
μ	Friction coefficient.

INTRODUCTION

By recognizing the function of the tribomechanical system and through a rich development of materials, equipment and methods, it seemed that all the problems associated with lubrication have been resolved. However, lubrication engineering still remains active. The goal is to develop tribomechanical systems that will be less environmentally harmful, while at the same time having high technical performances. Development of technical products is dependent on a number of both general and specific requests.

The basic role of lubricants i.e. lubrication is to reduce friction and hence prevent the wear of material surfaces whose relation is conditioned by relative mutual movement. However, it is essential that the lubricant also has other functional properties that will ensure its efficient application. These are above all good oxidation and thermal stability, corrosion protection property, compatibility with different materials, low foaming, ability to release air, good detergent-dispersant properties, good deemulsification, and the like. The use of a lubricant inevitably leads to the impairment of its performances. These negative changes are most usually caused by thermal load and/or influence of different kinds of pollution, to which lubricants are exposed during service.

Thermal loads may be generated as a result of high mechanical loads or prolonged exposure to increased temperatures. Different kinds of pollution are also a frequent cause of lubricant degradation. Gaseous combustion products, air, water, glycol, fuel, various process media, wear products, and other pollutants, may be the cause of a serious impairment of the condition of the lubricant, but also of the device itself.
That is why it is necessary to monitor changes in lubricant's performances, based on which one may determine a timely change of lubricant, thus prolonging the lubricant's service life and preventing any major failures of or damages to the system.

LUBRICANT SERVICE LIFE AND ANALYSIS

Numerous test methods are available for monitoring the change of lubricant performances, both conventional laboratory techniques and modern instrumental methods. Determining a lubricant's wear degree may be conducted through modeling or experimentally. Wear evaluation most frequently isn't unequivocal, which is why, in practice, various methods are used in combination. For this purpose, new methods are being developed, which will be simpler, because it is important to obtain data as soon as possible on the very application spot, which is very often in field. A common drawback of these methods is that they have not been standardized. The wear mechanism of a tribological lubrication system consists in the wear of contact surfaces, and lubricant consumption. If there is wear of the contact surfaces, there are wear particles present.

Regardless of the availability of numerous methods for diagnosing the physico-chemical and tribological changes of lubricants, in order to create a true picture of the condition of lubricants from the user system, it is of importance to satisfy the precondition of the possibility to obtain a representative sample. That is why it is extremely important to take the sample in a proper way.

Every sample has to be accompanied by documentation containing all relevant data, such as user name, lubricant name, sample label, date of sampling, date of sample delivery, type of device, lubricant quantity in the system, oil change date, refill data, number of operating hours, operating temperature, reasons for sample supply, and possibly other pieces of information that may be of use for an easier understanding of the actual problem in question and final interpretation of the obtained analysis results.

These data, along with the obtained analysis results, are the basis for the final lubricant condition interpretation, and hence also the evaluation of its further usability, possible maintenance intervention in order to resolve the problem, if any, and – in case of complaints – their justifiability determination.

VEHICLE AS A COMPLEX TRIBOMECHANICAL SYSTEM

Vehicles are very complex technical system which endures intense and different exploitation conditions. New vehicles are equipped as moving laboratories which do not lack data (in number and kind). Vehicle as a technical mean is a set of complex tribomechanical systems composed of range of subsystems that are also complex tribomechanical systems. They are composed of elements that participate in power transmission, moment of force from the motor, over transmissions (power transmitter, differential and other systems), to executive organs of a vehicle [1-2]. Power transmitter of a vehicle, Cf. Fig.1, is an example of a complex tribomechanical system.

This system is composed of elements for power and motion transmission (gears and splinted shaft), elements for information transfer (winches), for guidance (guideline), and for caulk (rubber gasket).

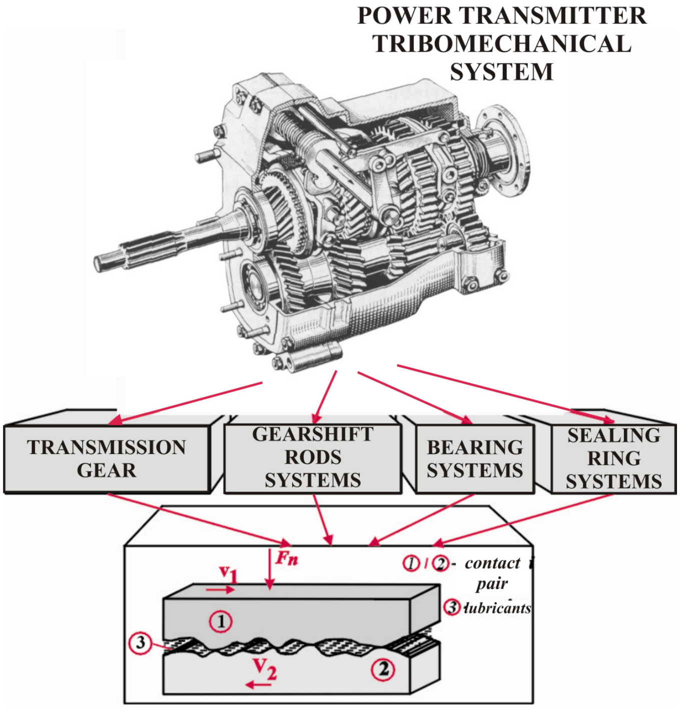

Fig. 1. Power transmitter as tribomechanical system [1-2].

All mentioned power transmitter elements as complex tribomechanical systems can be expounded and analyzed as a set of individual tribomechanical systems like gear wheels, bears etc. Also, every gear wheel can be analyzed (observed) as a separate element that is in contact. Finally, every cog side can be regarded as an elementary unit of tribomechanical system.

If the engine assemblies are considered from the aspect of tribomechanical systems (e.g. assemblies piston-piston ring-cylinder, cam-valve lifter, bearing-journal bearing) defined by tribological processes, it can be shown that the determination of the content of wear products, content of contaminants, state of lubricants and lubrication conditions have a significant influence on the implementation of maintenance of these systems [3].

We could emphasize the importance of monitoring oil for lubrication of tribomechanical engine and power transmitter assemblies, which provides that in the early stages of the functioning of the system identification of potential causes and phenomena that lead to damage and failure. Prognostication and detection of potential and/or current damage and failures in the system, checking the functionality of oil and determination of usage life are the main factors of the implementation of monitoring oil [3-4].

Modern trends of diagnosis in recent years go to the affirmation of the monitoring of oil, which has resulted in growth of interest of producers and users of oil. The reasons lie primarily in increasing the reliability, effectiveness, economy, and recently more and more present protection of the environment.

PHYSICAL-CHEMICAL AND TRIBOLOGICAL CHARACTERISTICS OIL

Lubricant characteristics can be divided in two groups:

1. **physical-chemical characteristics**: viscosity (dynamic-absolute-viscosity; kinematic viscosity), density, flash point, cloud point, pour point, volatillity, emulsibillity, deemulsibillity, foaming, air release, chemical composition, total acid number (TAN), oxidation stabillity, thermal stabillity, corrodibillity, corrosin protection capabillity, water content.
2. **tribological characteristics**: frictional force, frictional coefficient, wear intensity, contact temperature, intensity of increasing of wear products.

Today measuring equipment for evaluation and analysis of physical-chemical characteristics of lubricants is very developed; however, it is not the case with determination of tribological characteristics. Also, reliable methods (even parameters) are not completely defined [5].

Development of tribology as interdisciplinary science based on experimental investigations contributes to application and development of varied experimental equipment and devices-tribometers and tribometry as special area of investigations.

Identification of tribological processes, as a precondition to diagnosis of condition of real tribomechanical systems can be done in two basic ways; these are:

- Tracking of functional behaviour of real technical system and
- Model investigations.

Tracking of elements performances on real tribomechanical system elements alludes strictly oriented continual research without the possibility of varying and observing entrance parameters in wider diapason.

However, with model investigations, during which sampling of investigated element from real system and simulation of contact conditions are done, we can get a great range of data that indicate the condition of realistic system and predict it's further behavior with adequate reliability. However, before making conclusions based on tribometric investigations differences between real tribomechanical systems and investigations in model conditions.

The most of tribological characteristics are determined with defined standard tests, which can be seen in table 1. In that purpose, it can be used standard commercial tribometers like Falex, *Timken*, *Plint*, *Koehler*, *SRV,* etc.

Measuring system, applied on determination of tribological characteristics of tribomechanical system elements is composed as shown in Fig. 2 of:

- tribometer TPD-93 for measuring normal force, frictional force and frictional coefficient;
- thermometer for measuring temperature of oil and elements in contact;
- PQ-2000 particles quantification;
- microscope for measuring wear parameters (length h, width b, and depth of worn zone);
- Talysurf 6, computerized measuring device for measuring surface topography and wear parameters.