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TRIBOLOGICAL ASPECTS ON CHOICE OF LUBRICANTS AND MATERIAL FOR PASSENGER CAR GEARBOX ELEMENTS

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S u m m a r y

The energy crises and knowledge about limitations of natural petroleum reserves caused many researches with the aim to increase level of use of some aggregate for cars on one side and to test possibilities for application of alternative fuels and lubricants for motor cars to the other side.
However, use of lubricating oil of a good quality only does not provide both reliable and long work life. One of the principal prerequisite is coordination and optimisation of material, surface state, heat-treated and other treatment of surfaces along with lubricating oil characteristics at certain work regime and loading conditions.
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Keywords: *gearbox, oil, materials, SRV*

1. INTRODUCTION

An intensive development of traffic in the last decades is a result of a rapid industrial and general development as well as the increased population in the world. This is reflected in the consumption of fluids being highly present in traffic nowadays and according to some estimation it counts cca. 20% of a total consumption [1].

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During some previous decades more and more demands are placed in front of the automotive industry and cars as outputs, specially the demands to meet ecology criteria. An expectation that any car part should be accepted ecologically besides its functionality, reliability and durability it is also required the researches in their basic stages on new and/or improved materials.

During the motor car exploitation, its gearbox is exposed to time variable, dynamic and unsteady loadings being function to a series of factors as follows: motor car speed, quality and conditions of a road, way of driving, weather conditions etc. Any changes of the working regime cause the change of working load elements, force and coefficient of friction to the contact surfaces, increase of working temperature and of wearing as well as damage of elements to the synchronous system and the transmission of power in general. Dissipative processes occurred in that way are demonstrated in unwanted effects which can be identified in loss of material, energy, moving, functionality and reliability, reduce of life and increase of maintenance costs.

To reduce wearing and damaging of transmission elements they have to be oiled. Choice of the agents for transmission of power oiling depends on the transmission of power type and construction, material used for the elements, type and volume of loading, running conditions and working regime of the transmission of power and the motor car, way of oiling etc. Therefore the lubricating oils may be considered as constructive element and thus it is very important to know the composition of lubricating oils, their properties and effects. A lot of analyses showed that defects on the transmission of power elements occur because the lubricating oils are of poor quality or with not suitable properties.

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2. PARAMETERS AFFECTING TRIBOLOGICAL GEARBOX CHARACTERISTICS

2.1 Lubrication

Choice of lubricants for motor car gearboxes is a very complex work and depends on a large number of parameters. The highest influence to choice of lubricant quality is by motor car producers that base their requirements on various lubricant characteristics meeting specific aspects of design and results of gearboxes and cars.

The figure 1 presents percents of automatic gearboxes in USA, Japan and Europe [2]. In USA the participation of automatic gearboxes for the last 20 years is approximately constant and for the future they do not expect higher changes in percents. In Japan the automatic gearbox percents during the period of 1980-1990 is almost the same as in USA. The

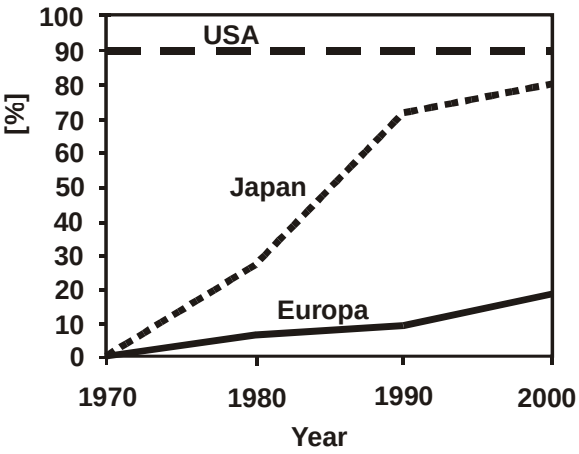


Figure 1: *Percents of automatic gearboxes at passenger cars structure [2]*

reason is a very low average speed of motor cars with a high stop and go regime.

Although at the end of eighty's and in the beginning of ninety's the prognoses showed a possible increase of percentages of automatic gearboxes in Europe it did not happen. The increase was noticeable only at high-class motor cars (for ex. Mercedes S-class, BMW series 7).

Lubricant is exposed to dynamic loads, from contact to sliding one, during its work and it goes through various regimes of lubrication. It brings to an increase of temperature on contact surfaces, increase of oil temperature and its degradation.

Therefore motor car producers require well lubrication of movable parts but also the

gearbox should endure high pressures, have minimal viscosity changes during operation, posses good oxidation, heat, chemical and shearing stability, enable gearing, reduce friction between contact surfaces, avoid or minimize mechanical wear and damages, outflow heating made by wear, protect gearbox element out of corrosion etc.

However, regardless the gearbox design, the most important factor while choosing gearbox lubricants is economy and necessity to reduce fuel consumption with parallel increase of gearing, reduce of losses expressed through wear and prolonged intervals for oil replacement.

Why the economy consumption of fuel is important? According to Gahagan [3] it is shown that use of multi grade engine and gearbox lubricants having reduced resistibility to flow potentially reduce consumption of fuels by 10% with relation to conventional lubricants. The environment is also protected, raw material sources are saved and costs for production and car maintenance are reduced.

Reduce of losses and increase of advantages of gearboxes is one of the priorities while designing the gearboxes. Reduce of friction on contact surfaces and its consequences may be reached by use of adequate lubricant formulation also. Then the basic oil, improver of viscosity index and a set of additives are the most influential parameters. They do not affect equally, but any of them may be dominant in certain area of Stribeck's curve (figure 2).

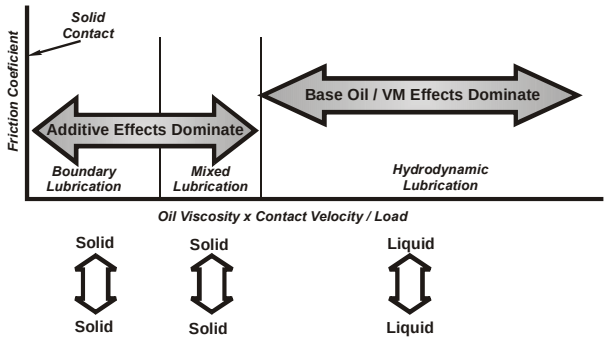


Figure 2: *The Stribeck curve [3]*

It is noticeable on the figure 2 that the set of additives is dominant under the conditions of limiting and mixed lubrication, while the basic oil and the viscosity index show their influence under the condition of hydrodynamic lubrication.

2.2 Materials

Influence of lubricants against friction and losses in gearboxes is evident and therefore a great attention is paid to it. However, in many cases, the action of lubricant does not reduce the friction coefficient and other unfavourable effects at contacts of surfaces in a relevant motion are partial and in some cases it is not expressive.

During exploitation on gears appear various damages of the toothed rim and the body.

The basic types of destructions and damages of toothed rim, depending on the gears operating conditions, their constructive and technological parameters, can be:

- Tooth fracture,
- Fatigue wear-pitting of the teeth working surfaces,
- Abrasive wear,
- Jamming or scoring,
- Plastic deformation of the materials surfaces layers,
- Damage of the tooth front.

Considerable reduce of sliding friction and increase of resistibility against various wear types may be reached also by right choice of contact surface material as well as the type and way of heat treatment. The heat treatments, carbonating and cementation, are the most used processes at gear manufacturing for motor car gearboxes

Recently used are the numerous methods such as the chemical conversions and changes of surface structure. Coating of the material having good antifriction characteristics and high resistibility to wear are more and more used as possible materials but due to a high cost price they are not applied widely in a series production for now.

3. AIM AND CONDITIONS OF THE RESEARCH

It has already been said that use of a quality lubricant is necessary but not a sufficient condition to reach a reliable and a long work life of a gearbox with its parallel advantages. One of a principal prerequisite is coordination and optimization of materials, heat and other treatments of surfaces with characteristics of lubricants at load conditions.

Such standpoint brought a definition of the research methodology that has an aim to

define a connection between characteristics of the contact surfaces (type of a material, heat treatment, roughness…) and characteristics of the lubricants and to recognize their influences on contact tribology characteristics. This includes model test and tests on real systems (the gearbox).

Determination of friction coefficient values under the condition of mixed lubricating can be carried out on high frequent device SRV. The steel ball under the load slides successively along the plate made of a material being tested (figure 3).

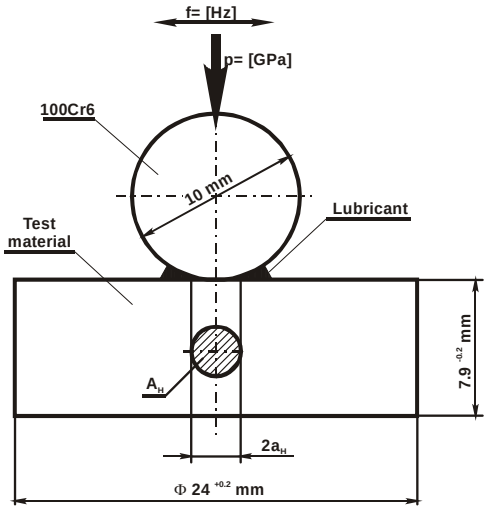
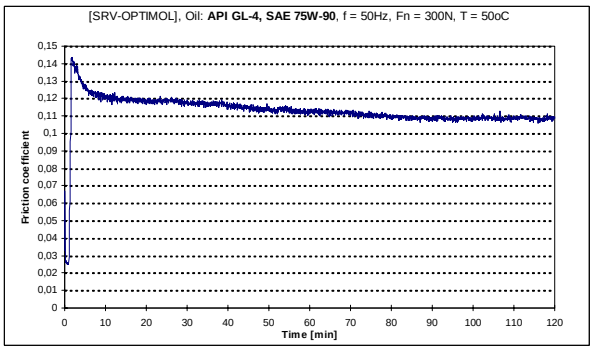


Figure 3: *Tribomechanical system (TMS) of balls-plates at testing operation on the SRV device*

Measuring of the friction coefficient is according to the DIN 51 834 standard [8].

4. TEST RESULTS

The figure 4 shows test results made on the SRV device. Measuring is done according to the standard conditions: frequency of 50Hz, the sliding path of 1000μm, temperature of 50°C, load of 300N, test time of 120min.



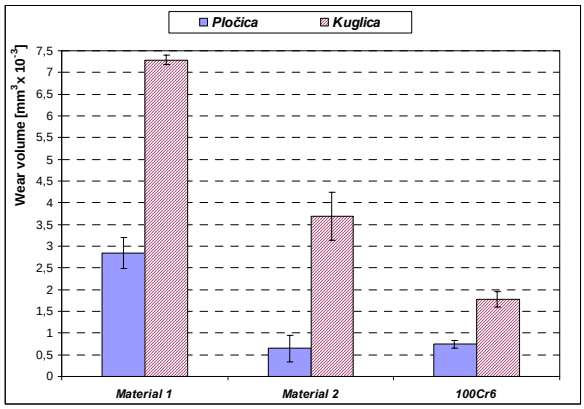
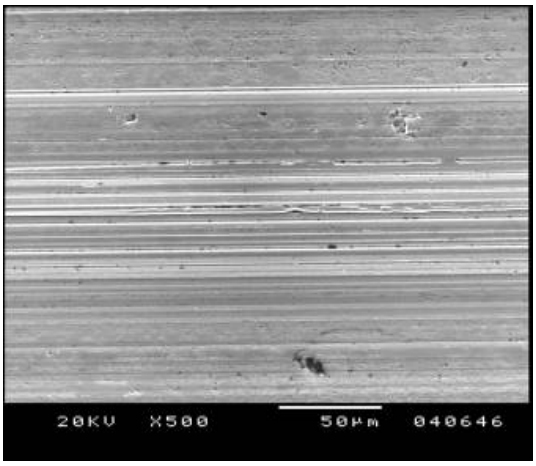
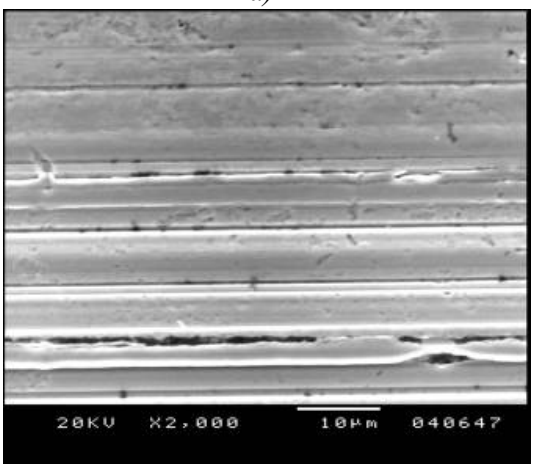


Figure 4: *Test results*

The figures 5a and 5b shows the sector surfaces on plates after testing, reached on electronic microscope SEM (Scanning Electron Microscope).



a)



b)

Figure 5: *SEM analyse of plate wear surfaces after testing operation (Oil: API GL-4, SAE 75W-90)*

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