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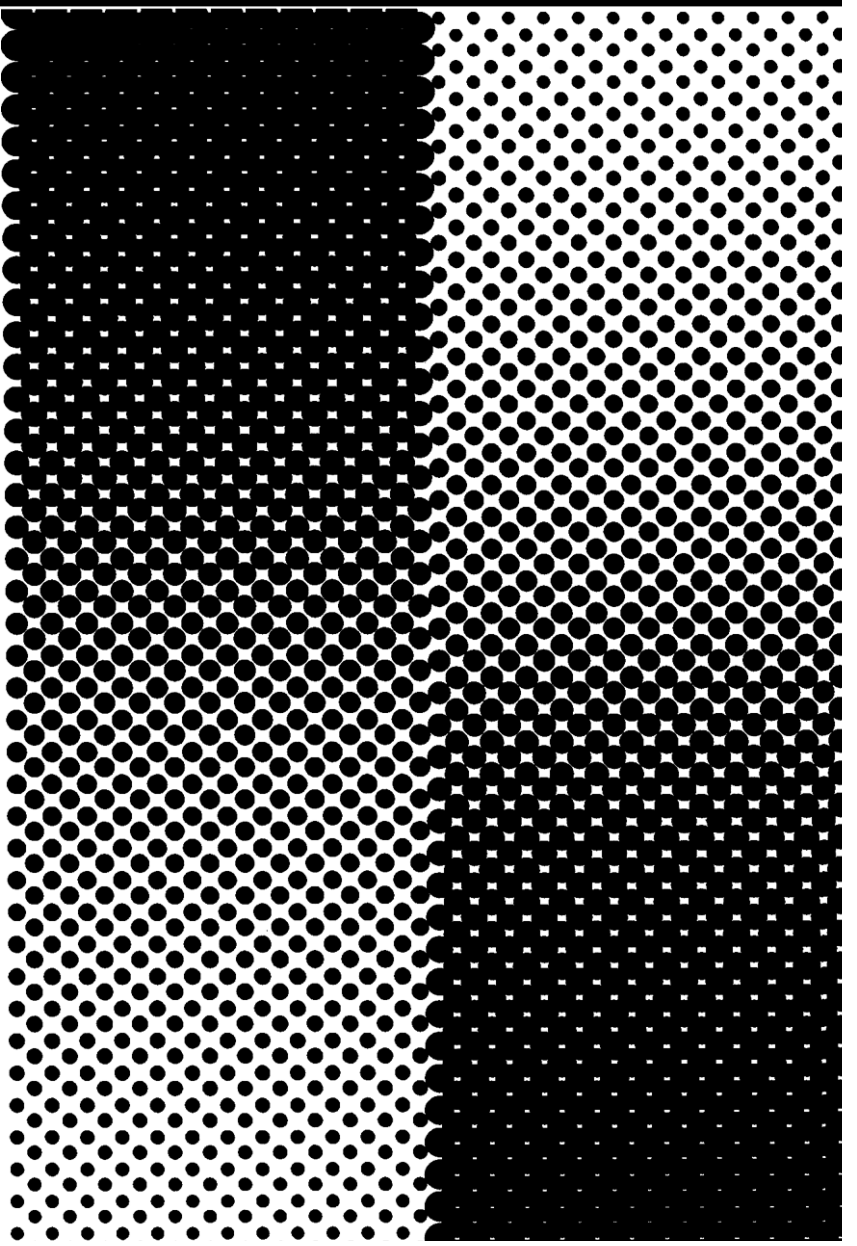

Journal of the Balkan Tribological Association is an International Journal edited by the Balkan Tribological Association for rapid scientific and other information, covering all aspects of the processes included in overall tribology, tribomechanics, tribochemistry and tribology.
The Journal is referring in Chem. Abstr. and RJCH (Russia).

Aims and Scope

The decision for editing and printing of the current journal was taken on Balkantrib'93, Sofia, October, 1993 during the Round Table discussion of the representatives of the Balkan countries: Bulgaria, Greece, Former Yugoslavian Republic of Macedonia, Romania, Turkey and Yugoslavia. The Journal of the Balkan Tribological Assosiation is dedicated to the fundamental and technological research of the third principle in nature – the contacts.
The journal will act as international focus for contacts between the specialists working in fundamental and practical areas of tribology.
The main topics and examples of the scientific areas of interest to the Journal are:

(a) overall tribology, fundamentals of friction and wear, interdisciplinary aspects of tribology;
(b) tribotechnics and tribomechanics; friction, abrasive wear, adhesion, cavitation, corrosion, computer simulation, design and calculation of tribosystems, vibration phenomena, mechanical contacts in gaseous, liquid and solid phase, technological tribological processes, coating tribology, nano- and microtribology;
(c) tribochemistry – defects in solid bodies, tribochemical emissions, triboluminescence, tribochemiluminescence, technological tribochemistry; composite materials, polymeric materials in mechanics and tribology; special materials in military and space technologies, kinetics, thermodynamics and mechanism of tribochemical processes;
(d) sealing tribology;
(e) biotribology – biological tribology, tribophysiotherapy, tribological wear, biological tribotechnology, etc.;
(f) lubrication – solid, semi-liquid lubricants, additives for oils and lubricants, surface phenomena, wear in the presence of lubricants; lubricity of fuels; boundary lubrication;
(g) ecological tribology; the role of tribology in the sustainable development of technology; tribology of manufacturing processes; of machine elements; in transportation engineering;
(h) management and organisation of the production; machinery breakdown; oil monitoring;
(j) European legislation in the field of tribotechnics and lubricating oils; tribotesting and tribosystem monitoring;
(k) educational problems in tribology, lubricating oils and fuels.

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Compiled by S. K. Ivanov, Zh. D. Kalitchin, J. P. Ivanova, M. I. Boneva, N. Evtimova and E. Tosheva.

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CONTENTS

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EXAMINATION OF MOTOR OILS IN EXPLOITATION OF AGRICULTURAL TRACTORS IN PROCESS OF BASIC TREATMENT OF PLOT

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ABSTRACT

On the heavy agricultural tractors MTZ 820 with 60 kW, used in the process of plowing, were examined the basic physical and mechanical characteristics of motor oils of renowned manufacturers in laboratory and exploitative conditions. Motor oils were investigated in exploitative conditions after spending 100 h working in the agricultural tractor engines. Tribomechanical characteristics assessment and evaluating the state of the tested motor oils were carried out based on the criteria used for the applications of lubricants, in order to determine the relations between the results obtained with different oils tested methods and procedures. Tests of basic physical and chemical characteristics of motor oils were carried out in accredited laboratory that meets the standards of ISO / EIC 17025:2006.

The aim of this study was to reach the optimum conclusion, by the examination of several types of motor oils in heavy agricultural tractors, which would enhance further the work of the tractor viewed through: better lubrication, better cleaning engines, improved sealing of the engine, better cooling, improved engine protection against corrosion, lower fuel consumption, etc.

Keywords: examinations, exploitation, motor oils, additive, physical and chemical characteristics, agricultural tractors.

* For correspondence.

AIMS AND BACKGROUND

The basic physical and chemical characteristics of many types of motor oils in heavy agricultural tractor (MTZ 820 with 60 kW) were examined in this paper in order to determine the degree of degradation of motor oils. First, there were tested the new unused motor oils, and then motor oils after spending 100 h working. Comparing unused and exploited motor oils we came to the conclusion how long oils could still keep working in exploitation.

For the test it was chosen a way of exploitation of agricultural tractors in the most complex agro-technical processes in agriculture-plowing process. This process is characterised by difficult tractor moving, working under full load, the presence of dust and others.

The most common problems of vulnerability of agricultural tractor engines of using motor oils of inadequate quality and untimely replacement of motor oils point out the consequences expressed as: engine overheating, motor oil pressure loss, increased noise, slow start, increase in oil sludge, oil leaks on the seals, damage valves and camshafts, rapid evaporation of oil, etc.[1,2]

The amount of dust in the air around the working tractors or other agricultural machines depends on soil conditions and types of treatment, and it ranges from 0.055 to 3.45 g/m^3 (Ref. 3). Bearing in mind that the best air purifiers miss at least 0.01% of total dust in the air from its finest fraction of particles, whose size is less than 5 μm in diameter, it is clear that external contamination of motor oils will be an inevitable phenomenon. Only with motor oils in good condition and high quality oil filters, it is possible to mitigate these negative effects[4,5] .

In addition to the scope of machine park, the amount of oil directly affects the quality of maintenance[6]. The usual practice is to change the oil after a certain number of moto-hours. As the interval in moto-hours may not be the only criterion, cases where the oil is changed are not rare, although its features are satisfactory for further work[3,6]. Polls results conducted on agricultural tractors operators showed that in more than 90% of the operator motor oils criterion was the number of moto-hours, and the remaining minority is the amount of fuel consumed[7].

Rationalisation of motor oils use is important task which can be successfully realised with oil substitution in motor timely. That provide maximum period of its use with enough and high-grade lubrication of motor at the same time. The most reliable procedure for motor oil substitution at agricultural tractors timely in definite terms of exploitation, is systematic tracking of oil state for the all period of use. Development of motor oils in the last decade, in terms of their characteristics increasing, unavoidably provokes need for the invention of appropriate possibility for the tracking of that characteristics. There are many methods and techniques for that realisation today. Since the control of rheological features is very expensive and is a process of long duration, accredited laboratories usually use only the

most important physical and mechanical features (if is not need different). These features can be determined with exploitation methods faster, easier and cheaper and their substitutions are in correlation with change of rheological features of the examining oil[8,9].

Reduce of friction and wear out of machine construction can be realised in many ways. One is, of course, the appropriate choice of construction, the selection of materials with small coefficient of friction and high resistance to wear out[10] and the third and most important is the use of appropriate types of lubrication field for their lubrication. At the same time, with the examination of motor oil state in exploitation and moment of this necessary substitution, in last years ecological treatment of fuel and lubrication field obtain more and more importance. The presence of high-quality oil in normal exploitation can make longer average working life duration of motors for few thousands moto-hours, but only with high-quality choice of motor oil, by correct exploitation and timely substitution. Timely substitution of oil in internal combustion engine is a very complex problem. It is an object of its substitution and definition of optimum borders of motor oils parameters[2,11].

CHARACTERISTICS AND PURPOSE OF OILS

The basic physical and mechanical characteristics of motor oils which are mostly used for diagnose are: flash point, viscosity at 40 (V_{40}), viscosity at 100 (V_{100}), index of viscosity, fuel contents, contents of water, mechanical dirt, total basic number (TBN), corrosive, insoluble grounds in benzene, oil spot, shear stability of oil, etc. Exploitation methods are: oil appearance, oil colour and values Oil-Chec and the Lubry number.

The purpose of motor oils is to lubricate engine, to clean, to block, to cold and protect engine of corrosion. It is not rare that with checking motor oils state, it can be concluded about the immediate condition of engine in which it was. For example, contents of Ni and Zn in oil sample point to damage of some bearings on crank shaft, even damage of very crank shaft: content of B points to probable presence of antifreeze in oil, increase content of coke leads to possible bake piston rings.

EXPERIMENTAL

The basic physical and chemical motor oils characteristics of renown producers were examining at tractors MTZ 820 of power 60 kW which worked in process of basic treatment of plot. Basic information about the tractors that were used in examining the process of plowing farms is shown in Table 1.

Table 1. Basic characteristics of the tested motor oils

Oil characteristics	Types of investigated oils used on agricultural tractors		
Manufacturer	Modricha	Mol-lub	Valvoline S.T.O.U.
Name of oil	Maxima super	Mol turbostar	Partner 17058
Viscosity	SAE 15W-40	SAE20W-50	SAE15W-40
Qualitative level	–	API CD, CF/CE, CCMC D4/G2	API CF-4, CF/CE, API GL4/5

Physical and chemical characteristics of motor-oil for 100 moto-hours were examined in accredited laboratory for the examination of lubrication according to JUS ISO/EC 17025 standard. There were used motor oils of the following producers:

- Maxima super – Modricha (viscosity SAE 15W-40), sample is taken after 139 moto-hours;
- Mol turbostar – Mol lub (viscosity SAE 20W-50), sample is taken after 126 moto-hours, and
- Partner 17058 – Valvoline S.T.O. (viscosity SAE 15W-40), sample is taken after 97 moto-hours.

The laboratory physical and chemical characteristics of the examined motor oils were:

- V_{40} – viscosity at 40 (mm^2/s),
- V_{100} – viscosity at 100 (mm^2/s),
- IV – index of viscosity,
- flash point (°C) and
- TBN number (mg KOH/g).

In exploitation terms, the examining dimensions of oil were:

- OilCheck number,
- the Lubry sensor number,
- colour of oil, and
- oil appearance.

The samples of used oils are taken from motor crankcase of terrain. These samples were situated in previously washed and dryed numbered bottles, plastic, with original caps, which were then charged, put in appropriate wooden box suitable for the transport and carrying. Parallel with taking of the used oils after 100 h spent in work, the samples of unused oils were taken, too. In order to testify the measured dimensions which were received by laboratory and exploitation methods, the appropriate unit of measure and their marks were used, which is shown in Table 2. Specifically complex problem in methodology access of this work is that the dimensions which express physical and chemical motor oil characteristics are of different nature: descriptive, relative, proportional and absolute. Based on that, the estimation of the degree of using of motor oils examination was done on the

Table 2. Allowed limit values for the control of examined motor oils state

Measured dimensions	Mark	Unit of change	Source of change	Allowed amplitude of fall
Kinematic viscosity at 40°C	V_{40}	%	estimate of using in application of motor oils	10÷20%
Kinematic viscosity at 100°C	V_{100}	%		
Index of viscosity	IV	%		
Total basic number	TBN	mg KOH/g	ASTM D 664 (JUGOMA NC 2)	50%
Flash point	COC	%	SRPS. B.H8.027	maximum 25%
The Lubry sensor	LS	–	plan	5
OilCheck	CO	–	plan	46

basis of proportional falls which have their desirable and maximum amplitudes of retreat which are partly taken from experiences which are used in area of lubrication application (Table 2). In this way it will be solved very effectively the problem of mutual comparison of statement changes.

For Table 2 it is necessary to note that the allowed limits of amplitude fall are variable in case that producers of lubrication or motors explicitly do not demand different.

The state of used moto-hours at tractor engine MTZ 820 at the beginning of examination was:

- 4914 moto-hours for the Maxima super,
- 1659 moto-hours for the Mol-turbostar,
- 2225 moto-hours for the Partner 17058.

RESULTS

The initial values of the physical and chemical characteristics of non-used motor oils patterns are shown in Table 3. The values of these characteristics for the samples examined after 100 moto-hours are shown in Table 4.

Table 3. Initial values of physical and chemical characteristics of motor oils

Examined parameters	Maxima super Modricha	Mol turbostar Mol-lub	Partner 17058 Valvoline S.T.O.U.
V_{40} (mm^2/s)	119.43	190.64	103.8
V_{100} (mm^2/s)	14.96	19.66	14.38
IV	129	118	142
Flash point (°C)	230	220	208
TBN (mg KOH/g)	7.84	12.64	10.43

Table 4. Physical and chemical characteristics of examined motor oils at agricultural tractors after 100 moto-hours

Examined parameters	Maxima super Modricha	Mol turbostar Mol-lub	Partner 17058 Valvoline S.T.O.
V_{40} (mm^2/s)	111.32	160.23	90.55
V_{100} (mm^2/s)	14.35	16.78	12.64
IV	131	112	136
Flash point (0 C)	224	222	202
TBN (mg KOH/g)	6.56	10.03	9.12
The Lubry sensor	4	2.4	3.2
OilCheck	42	18.4	17.3

DISCUSSION

Maxima super Modricha oil after exploitation of 139 moto-hours showed variable results. Indices of changing viscosity and flash point based on the data in Table 5 move in declare limits (<10 %) and show satisfied values for that time. On the basis of measured value of viscosity V_{40} oil could stay in exploitation maximum till 330 moto-hours. Rush reduce of TBN number (aproximately 17%) very probably is a result of additive decay, based on which it can be used till 440 moto-hours (Fig. 1). The measure values of oils state with the Lubry sensor and OilChecc machine are carried out 4 more times for sample 42 and point out to identify values of oil contamination. Rush increase, the Lubry sensor number point to undoubtedly obstruction of oil filter.

Exploitation of Mol turbostar oil points to amplitude demotion of all indices of the examined physical and chemical characteristics, probably as a result of the engine current state. Viscosity at 40°C has the most critical value whose retreat from beginning value reaches 17% (Table 5), which can point to bad blocked areas with the most probable building of diesel fuel and irregular combustion. On the basis of the measured values of index of viscosity at 40°C (V_{40}) oil can be found

Table 5. Proportional retreat of physical and chemical characteristics of the examined motor oils

Parameters	Maxima super Modricha (%)	Mol turbostar Mol-lub (%)	Partner 17058 Valvoline S.T.O.U. (%)
V_{40} (mm^2/s)	93.2	84	87.2
V_{100} (mm^2/s)	96	85.3	87.9
IV	101	94.9	95.8
Flash point (°C)	97.4	101	97.1
TBN (mg KOH/g)	83.7	81.5	87.4

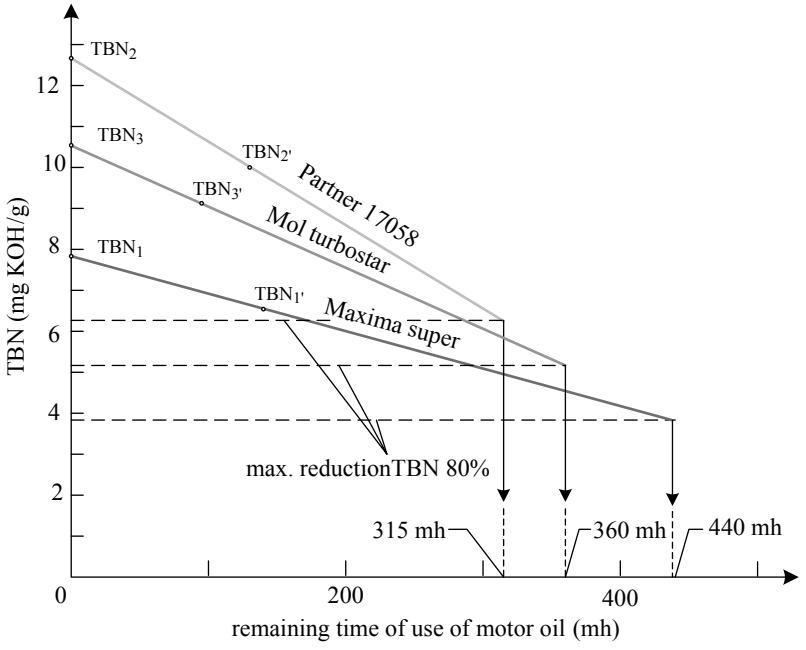

Fig. 1. Determination of the optimum remaining time of use of the examined motor oil on tractors MTZ 820 based on measured values of TBN after 100 moto-hours

in exploitation maximum till 160 moto-hours and on the basis of the measured values of TBN number – till 315 moto-hours (Fig. 1). The value of measured with Lubry sensor at 36 moto-hours carry out 0.8 and at 126 moto-hours 2.4. Based on that time of use it would reach till 355 moto-hours. The change of the Lubry sensor number value is a result of, very probably, adding of more quantity of fresh oil which will reduce the dielectric constant. Examination value received by Oil-Check carries out 18.4 and is identical to the value of contamination obtained by the Lubry sensor. In this case examinations of exploitation method show different results of measures of those which are received by laboratory analyses.

The sample of Valvoline motor oil Partner 17058 which is taken after 97 moto-hours points to general equalising of demotion and contamination which is substantial. Percentages of fall IV carry out (approximately 4%) and viscosity at 40° and 100°C (approximately 13%) (Table 5). On the basis of the measured values of viscosity at 40°C (V_{40}) oil could be found in exploitation maximum till 146 moto-hours, and on the basis of TBN up to 360 moto-hours (Fig. 1). After 31 moto-hours the value measured by the Lubry sensor machine carry out 0.5 and after 97 moto-hours 3.2. The increased trend of the values of LS number points to eventual blockage of the filter for fuel and oil. Value received by OilCheck machine carries out 29.

Based on the appearance of all 3 examining samples of the used motor oils, it can be concluded that all taken samples have dark-green colour which appears for sure like a result of thermo-oxidation demotion.

At Mol turbostar oil sample after 100 moto-hours the scent points to the presence of diesel fuel in itself, very probably because of incorrect system for fuel supply. In contrast to that, diagnosis by scent at samples of Maxima super and Partner 17058 does not load at possible negative processes which are developed in given oils or motors.

CONCLUSIONS

The paper represents laboratory testing methods and exploitation of motor oil in the process of agricultural tractors plowing at 100 moto-hours. It should be noted that some indicators of physical chemical properties of test oil in the paper pointed out that in some oil samples significant degradation is present, but it can still remain in operation more than 100 moto-hours.

The conclusion of this work is that motor oils on agricultural tractors even in difficult agro-technical terms, such as the process of plowing the land, may remain in the engines and over 100 moto-hours, but it is recommended that it change the max to 100 moto-hours. The reason for this lies in the fact that agriculture is a seasonal activity that affects the change of oil and depends on: the complexity of modern farming operations, the time limit of the usability of oil, climate setting, conservation and other machines. Similar results and recommendations to keep the motor oil performance in the interval from 100 to 150 moto-hours are presented by the authors in Refs 3 and 6.

Results showed that age, wear, contamination and origin of the engine of agricultural tractors, as well as conditions of exploitation relativise the intervals of engine oil use. Similar results were reported by the authors of Ref. 2.

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