R. Kuti
Széchenyi István University, Faculty of Mechanical Engineering, Győr
Hungary

F. Könczöl
Hungarian Air Force, Veszprém
Hungary

L. Csapó
Hungarian Defence Forces, Győr
Hungary

Cs. Papp
Széchenyi István University, Faculty of Mechanical Engineering, Győr
Hungary

L. Földi
Faculty of Military Science and Officer Training, University of Public Service
Budapest
Hungary

Á. D. Tóth
Széchenyi István University, Audi Hungaria Faculty of Automotive Engineering, Győr
Hungary

Selection of Engine Oils with Tribological Examinations Applicable to Specially Operated Diesel Engines

In recent times, many specially engineered diesel engines built in the 1980s are still used in different areas, for which the suggested engine oils are no longer available. These engines are operated reliably in military combat vehicles, electricity generators, and tracked machinery, thus it is essential to examine what engine oils are suitable for their operating conditions and may be used as their engine oil. The aim of our research is to conduct the tribological examination of an oil sample taken from a V-6M type naturally aspirated Diesel engine and the oil prescribed by the manufacturer. After evaluating the results, we determine which type of oil is applicable in the engine to achieve safe operation and a long lifetime.

Keywords: *internal combustion diesel engine, engine oil, tribological examination*

1. INTRODUCTION

For the safe operation of internal combustion engines, it is necessary to have proper lubrication, which is only achievable with the application of proper lubricants. To increase the lifespan of different moving structural elements, improve operation, and consume fuel effectively, engines need a liquid-state machine element, which is lubricating oil. Oil provides lubrication as a lubricant, its task is to minimize wear and to keep the optimal value of friction coefficient [1]. Although it can be stated, that engine oils do not only have a lubricating function, they also have other important tasks, such as sealing, for instance, between the piston ring and cylinder wall, which seals high-pressure, hot gases. Oil is an excellent cooling medium, and it gives heat off through the radiator. It has anti-corrosion and cleaning roles since wear and burning residuals are transported from lubrication points. It can be mentioned that noises occurring in the engine are partly damped by oil since it functions as a vibration damper [2]. If the recommended oil is not used in the engine during operation or the periodic oil change is omitted, then oil cannot fulfill its lubricating function, and machine elements may be crucially damaged. The main reason behind engine damage is wear processes on the surfaces of engine parts in contact, which are capable of causing problems in the operation of the engine. In more severe cases, this leads to an inoperative engine. These wear processes are related to lubricants and lubricating areas to a significant extent [3]. This wear occurring during operation cannot be detected by computerized diagnostics that are used nowadays [4]. Wear processes can be detected by tribological examination of the oil without disassembling the engine [5]. As a matter of fact, tribological investigations are also critical because they report the changes in the lubrication parameters of oil [6]. As long as the lubricating ability of oil is determined, engine damage can be prevented with an oil change (using the proper lubricant) [7]. This is an important task because repairing and renovating processes of specially operated engines are complicated, time-consuming, and expensive [8]. It means a further problem if there is no available oil that is recommended by the manufacturer.

Regarding this kind of problem, there is no available literature resource that can provide the proper solution. In our opinion in this case, it is advised to conduct the tribological examination of a factory and available oils, after that the proper one can be chosen with the analysis of results. The novelty of our research work is that we conduct a tribological examination of the lubricants available in the case of a given engine and with the help of the results we choose an optimal oil for operation.

The investigated engine is the V-6M type naturally aspirated diesel engine, which is still used today in combat vehicles in Hungarian Defence Forces and in civil areas such as electricity generators and tracked vehicles. In our research work, we took oil samples from the engine of a 1Sz91 type-armoured fighting tracked vehicle (which was the recommended factory engine oil), that were investigated in detail. The next step was to examine the tribological parameters of similar and available engine oils. Our goal is to select the proper oil for the investigated engine with the help of the results. Moreover, we would like to contribute to the more extended operation of these kinds of engines.

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Correspondence to: Dr. Rajmund Kuti, Széchenyi István University, Faculty of Mechanical Engineering, Informatics and Electrical Engineering, Győr, Hungary,
E-mail: kuti.rajmund@sze.hu
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2. INVESTIGATIONS

Before our research work, we examined several older built, however, today also operated, high-performance diesel engines. We chose a V-6M-type engine (Figure 1.) because factory oil remainings were found for this engine that was enough to perform tribological inves–tigations.

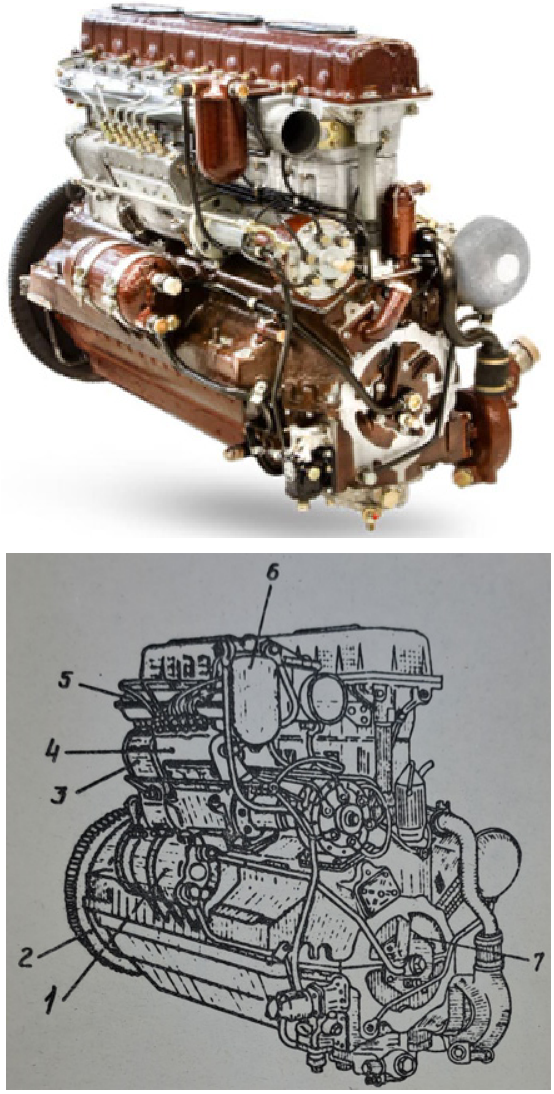

Figure 1. V-6M type diesel engine (top) and main parts of the engine (bottom) [9] 1- oil filter; 2- flywheel; 3- RPM regulator; 4- fuel pump; 5- intake pipe; 6- fuel filter; 7- central oil distributor.

No engine oil is available for the other engine types recommended by the manufacturer. Engine oil has a vital role in the operation of engines since it reaches every engine part, thus the usage of improper oil leads to the wear and crucial damage of engine components in the short term. It is significantly important to use the appropriate oil in high-performance, specially operated engines. V-6M type engine is a 6-cylinder, inline, na–turally aspirated, 4-stroke, DOHC diesel engine con–taining 4 valves at each cylinder. Its cubic capacity is 18000 cm3, and its performance is 206 kW (280 BHP) [9]. These engines were manufactured in the Soviet Union, to their operation MT16P-type special engine oil was used, which was also produced in the Soviet Union. This oil has not been purchased in Hungary since the 90's. Hungarian Popular Army adapted 1Sz91-type tracked carrier vehicles in the 1970s, different structures were built on them, and V-6M engines were mounted in them.

Further supply continued in the 1980s. The inves–tigated vehicle is now mobilisation-blocked and is on stand-by. During its shutdown, factory-type MT16P type oil was in its engine, operated for 50 hours. We managed to gain oil samples from this engine without disassembling it. We examined more oil samples as references. We also managed to obtain MT16P-type en–gine oils from military remains. We received an oil sample from a corporation where a V-6M engine is used in a generator, in which a so-called MT oil, which was introduced in the 1990s as a substitute, was used. According to our experience, this oil has to be changed earlier than the manufacturer's recommendation (100 op. hours), since oil pressure decreases were observed.

Furthermore, we examined ÖMV Panzer type 20W50 oil as well, used in the military vehicles of the Hungarian Defence Forces. This oil was developed for increased strain on military vehicles. The investigated oil samples were first analyzed under laboratory circumstances in the LubCheck laboratory of MOL-Lub Ltd. This analysis provides information about the oil sample in three main groups: oil status (viscosity and additive element con–tent), contaminations (fuel, cooling water, soot, and their elements), and wear elements (e.g., aluminum, iron, or in the case of older engines lead). These parameters provide technical information about the actual status of the oil sample and the reservoir of the additives and the technical report also contains a technical advisement about the investigated sample. In the case of investigating an oil sample taken from an operating machine, it is necessary to analyze the beginning state of the oil sample, so a small amount of lubricant should be provided from the lubricant that was taken from the bottle of oil. The tec–hnical report also uses a 3-color marking for each mea–surement unit: white if there is no big issue detected, yellow for a warning sign, and red if the value reaches a critical value.

The chemical oil analysis was followed by tribo–logical experiments with the lubricant samples. An Optimol SRV®5 tribometer [10] was used for the experiments with a ball-on-disc measurement setup. During this type of measurement, the ball is moved on the flat surface of the disc specimen with a predefined movement pattern while the ball is pressed onto the disc surface with a predefined normal force. Standardized ball and disc specimens [11] were used for our investi–gation, and these specimens were purchased directly from the manufacturer of the tribometer (Optimol Inst–ruments GmbH., Munich, Germany). The Ø10 mm ball specimen is made of 100Cr6 material (1.3505), its hardness is 60 ± 2 HRC and its surface is finished to the R_a value of 0.025 μm ± 0.005 μm. The Ø24 mm × 7.9 mm disc specimen is also made of 100Cr6 material (1.3505), and it is vacuum arc remelted and its heat treatment is spheroid and annealed to obtain globular carbides. Its micro-hardness range is between 710 and 820 HV (62 ± 1 HRC). The test surface of the disk is first grinded followed by lapping and is free of lapping raw materials: R_z between 0.5 and 0.65 μm, R_a between 0.035 and 0.05 μm, R_{PK} between 0.02 and 0.035 μm, R_{VK} between 0.05 and 0.075 μm.

Before the tribometer experiments, the specimens were thoroughly cleaned in an ultrasonic cleaner filled with brake disc cleaner fluid at 50°C temperature for 15 minutes to remove all the microscopic particles and contaminations that are not required for the tribological tests. This cleaning process is important to provide a near-equal starting condition of the specimens in the case of each tribometer test. The tribometer itself contains its own peristaltic oil circuit, which enables to provide a continuous oil flow (225 ml/h) right onto the contacting surfaces of the specimens and the oil can be heated separately from the testing specimens as well, which enables a much more constant oil temperature during the whole test. The test was carried out with a sinusoidal oscillation movement pattern with a movement stroke of 1 mm and a fre–quency of 50 Hz. The measurements were repeated under two different temperature conditions (80 and 110 °C) corresponding with the existing ISO 19291:2016 standard to analyze the oil samples slightly under and above the optimal operational conditions. Both the specimens and the oil sample were preheated separately up to the selected temperatures. The program consists of two main steps: a 30-second run-in phase with a lower loading condition (50 N) to ensure proper lubrication film between the testing specimens and a 2-hour long phase under 200 N constant load, simulating a high contact pressure inside the engine. The friction coef–ficient value of the operating system was saved with the high-frequency data saving mode of the tribometer during the whole test, and the integral average value of these friction coefficient data was calculated automatically by the controlling PC of the machine, which provides a great average value of the investigated tribosystem.

The tribometer tests were always followed by another ultrasonic cleaning and a thorough micro–scopical analysis of the worn surfaces. A Keyence VHX-1000 type digital microscope was used with an objective of maximum 1000× magnification to produce high-resolu–tion pictures about the worn surfaces. The microscope enables to execution of geometrical measurements on these pictures so the mean wear scar diameter (abb. MWSD) could be calculated corresponding to the ISO 19291:2016 standard: the wear scar diameter was measured on the surface of the ball spe–cimen parallel and perpendicular to the sliding direction and their average value was considered as MWSD value. Paulovics et al. [12] proved that there is a good correlation between the MWSD value and the measurable wear volume parameters, so we have decided to measure this value instead of the wear volume, which can only be defined with a more complex and more time-consuming method.

3. EXPERIMENTAL RESULTS

3.1 MT16P engine oil

The oil sample which was taken from the V-6M type engine is significantly different from the sample with zero working hours: its color is deep black and moves differently in its laboratory glass. It can be assumed that this used oil sample contains a significant amount of soot and wear particles. Besides this, its viscosity is also assumed to be different from its reference sample.

Figure 2 illustrates the comparison of the used oil sample taken from the V-6M type engine with 50 working hours and its reference oil sample with 0 working hours on two different measurement temperatures. Different tendencies can be defined in the case of the friction coefficient and mean wear scar diameter values: lower friction coefficient values were detected in the case of the used oil sample compared to the new one, while the opposite tendency can be defined in the case of the measured mean wear scar diameter values. It is evident from the measured data, that the measured values are higher in the case of the 110°C testing temperature with the used oil, however the new oil works similarly in the case of both temperatures. This result proves that this engine lubricant is designed to protect the contacting surfaces under multiple temperature conditions during engine operation. Used oil provides lower friction but more wear, which can usually be explained by a measurable value of fuel or coolant in the engine oil, which decreases the kinematic viscosity of the lubricant. This decreased viscosity leads to decreased frictional losses because less energy is needed to move the oil molecules, but this process increases the wear because of the thicker oil film between the contacting surfaces. This is the reason why the chemical lubricant analysis is crucial because this hypothesis can only be proved with this kind of measurement.

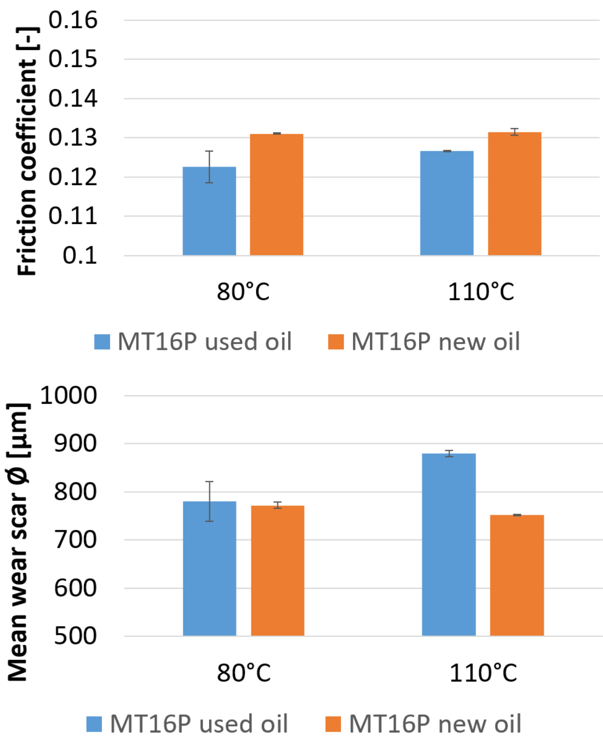

Figure 2. Friction coefficient (top) and mean wear scar diameter (bottom) comparison of used and new oil sample of MT16P on 80 and 110°C testing temperatures. (Source: Authors compilation)

Figure 3 represents the acquired digital microscopic images of the ball specimens after measurements with unused and used MT16P lubricant samples under the two investigating temperatures. It can be defined that the most dominant wear mechanism is abrasion because the loss of wear grooves parallel to the sliding move–

ment is visible. Besides, a significant amount of fatigue wear holes can only be identified on the surfaces in the case of the unused lubricant. This fatigue wear is not present in the case of the used lubricant, probably because of the soot and wear particles that are present in this lubricant sample.

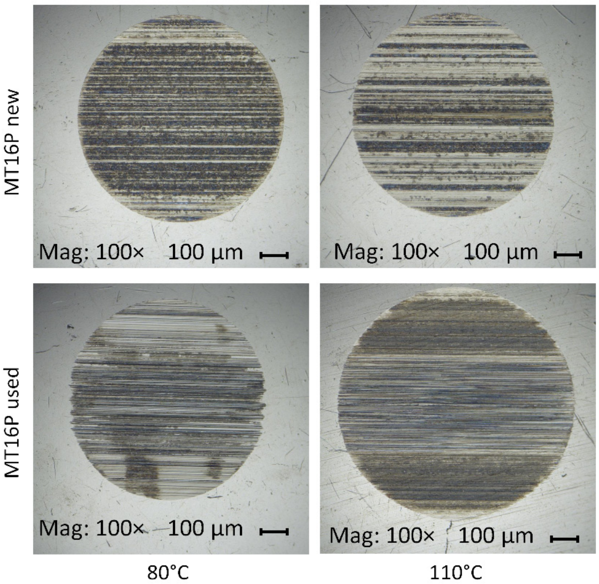

Figure 3. Digital microscopic wear images on the ball spe–cimens in the case of measurements with new (top) and used (bottom) MT16P type of engine oil under 80°C (left column) and 110°C (right column) temperature, acquired with 100× magnitude. (Source: Authors compilation)

The chemical analysis result of oil is listed in Table 1. The data shows that the kinematic viscosity decreased around the two temperature values of the tribological experiments (10% viscosity decrease at 100°C). Furt–hermore, significant changes can be defined in the oil status indicating oil additives' depletion. More than 90% of calcium content is depleted, which decreases the dispersive property of the lubricant. The wear molecules can be covered with worse efficiency. The phosphorous and zinc content of the oil also decreased (around 90% of these additives are depleted), which is mainly present in the oil as the zinc dialkyl dithiophosphate is the main wear-decreasing additive. The sulfur content of the engine oil was more than double, which was marked as a critical red color, because an increased sulfur content only increases the corrosion wear of iron surfaces, resulting in a decreased component lifetime. The dec–rease in base number indicates that the engine oil cannot effectively bind the acidic byproducts of combustion. The measurable soot content was also slightly increased, but this value is expected according to the known 50 working hours of the oil. The LubCheck report marked Al and Pb elements with a warning yellow color, which means some wear to be expected at the plain bearings and engine components made of aluminum (e.g. piston, plain bearings, or crankshaft) and these components should be further examined whether they should be replaced. The measured amount of soot and wear particles inside the used lubricant provide different wear mechanisms on the surfaces: usual fatigue wear holes are removed by a more extreme amount of abrasive wear because of these particles in the case of the used lubricant variation.

Table 1. The most important measured data about the MT16P lubricant samples during the LubCheck analysis. (Source: Authors compilation)

Parameter	MT16P used	MT16P new
Kinematic viscosity on 40°C [mm^2/s]	178	139
Kinematic viscosity on 100°C [mm^2/s]	15.9	17.4
Ba content [mg/kg]	1637	0
Ca content [mg/kg]	258	2920
P content [mg/kg]	93	791
Zn content [mg/kg]	79	993
S content [mg/kg]	12,674	5399
Base number [mg KOH/g]	1.2	8.8
Fuel content	No	No
Water content	No	No
Soot [A/0.1 mm]	0.53	0.25
Al [mg/kg]	26	0
Fe [mg/kg]	16	0
Cu [mg/kg]	22	0
Pb [mg/kg]	37	0

3.2 Comparison of lubricant alternatives

The three analyzed unused oil samples showed similar properties at first sight. A significant difference was observed in an investigation without machines: the MT oil sample could be moved by gravity more easily than MT16P and ÖMV Panzer oil variants, which assume a lower viscosity value on laboratory temperature. The ÖMV Panzer 20W50 type of engine oil was previously analyzed by the authors with the same investigation methodology and the results were already published in a previous journal paper [13], this evaluation only com–pares the previously published results with the newly produced results with MT16P and MT lubricant vari–ations.

Figure 4 presents the measured friction coefficient (top) and mean wear scar diameter (bottom) values in the case of the oil variations under two testing tem–peratures. It is clearly visible that each lubricant variant operates with a friction coefficient of around 0.13, however, the ÖMV Panzer shows an increased value under 110°C testing temperature (approximately 10% increase). The tendency is unclear when the mean wear scar diameter values are observed: the original MT16P is not a temperature-dependent liquid, while its com–monly used alternatives do so (MT variation 8%, while ÖMV Panzer variation 30% MWSD increase). How–ever, both alternative oil samples provide lower wear losses than the original, which correlates with the con–tinuous development of the engineering and chemistry areas. It is essential to mention that the tribological results are significantly viscosity-dependent. Hence, the friction and wear results are sometimes difficult to compare, especially in the case of the MT variation, because its viscosity is assumed to be lower, based on the analog first-sight observation. Analysing the ÖMV Panzer 20W50 and its application, clearly proves that this type of engine oil was mainly produced for military engine applications where a low amount of wear and lifetime have higher priority than the decrease of frictional losses and so increased fuel efficiency.

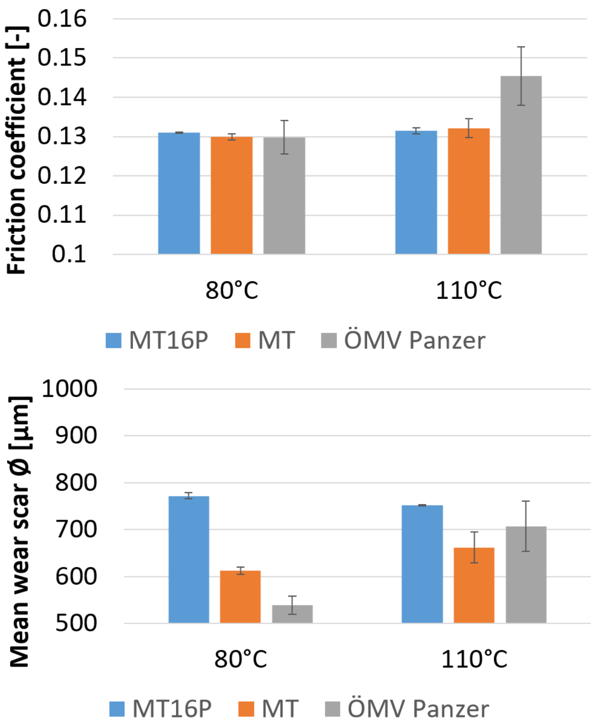

Figure 4. Friction coefficient (top) and mean wear scar diameter (bottom) comparison of new oil sample of MT16P, MT, and ÖMV Panzer 20W50 engine oils on 80 and 110°C testing temperatures. (Source: Authors compilation)

Figure 5 represents the acquired digital microscopic images of the ball specimens after measurements with unused MT16P, MT, and ÖMV Panzer lubricant samples under the two investigating temperatures. The digital microscopic images show an interesting ten–dency: the amount of the visible, parallel to the sliding direction wear grooves, slightly decreased in the case of MT lubricant variation, and significantly decreased in the case of ÖMV Panzer sample. Furthermore, the area of black regions on the surfaces is also higher in the case of the MT and ÖMV variation, representing burned oil on the surfaces. It can be explained by the lower amount of wear (wear depth) because a slight amount of oil burning is a natural behavior during these tests, but an increased depth of wear removes this layer and reveals the metal-colored surface via abrasion.

The removed or thinned oil layer from the surface is a self-generating process, because the surface cannot be protected via this layer accordingly and the con–tinuously increasing amount of removed material from the contacting surfaces increases the wear depth. It also can be defined that just a tiny amount of wear grooves can be observed in the case of the ÖMV Panzer variation, the surface seems to be plainer (similar to ground surfaces), which shows better wear protection property of this sample. The results of the LubCheck analysis should be analyzed to find the explanation for these observations.

Table 2 shows the most important measured parameters of the unused lubricant samples. It is visible that there is a massive difference between the original MT16P and its replacement lubricant for electric generators (MT): almost in every investigated aspect, the MT is worse than the original, and it can be the reason why this type of lubricant must be replaced earlier in the case of these V-6M engines used for electricity generator. The ÖMV Panzer 20W50 oil is a better variation for the replacement of the original, today not purchasable MT16P variation, and this is also proved by the measured numbers: its viscosity is slightly higher, and it contains more additive elements (Ba, Ca, P, Zn) which correlate with the tribometer results, that the ÖMV Panzer 20W50 provides better wear resistance to the investigated system than the original MT16P. The Ba element is used for a dispersant additive (e.g. $BaSO_4$) that is used for older engine oils to bind the soot particles. Ca is usually used as an element of a detergent additive in the form of $CaCO_3$, which can neutralize the acidic molecules produced during combustion. P and Zn are usually used for tribological friction and wear-decreasing elements, for example, ZDDP (zinc dialkyl dithiophosphate), which binds itself to the metallic surfaces, forming a protective layer and avoids metal-to-metal contact during the operation of the engine [14].

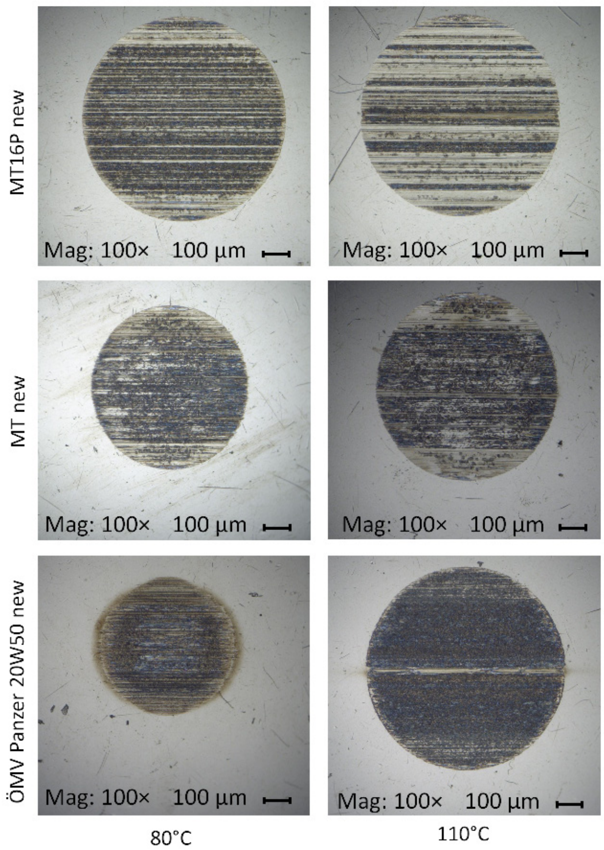

Figure 5. Digital microscopic wear images on the ball specimens in the case of measurements with MT16P (top), MT (middle), and ÖMV Panzer (bottom) type of engine oil under 80°C (left column) and 110°C (right column) temperature, acquired with 100× magnitude. (Source: Authors compilation)

According to the results generated by tribometer, mic–roscope, and chemical oil analysis, it can be defined that the available engine oils were continuously developed year by year to provide better lubricants to machines and not just for the newly invented engines. The deve–lopment can be observed mainly in the applied additives (tribological additives or contamination binding addi–tives) and their concentration. This additive concen–tration difference and the significantly lower viscosity values between the original MT16P and its replacement MT variation of lubricant can be the reason why the engine oil should be replaced more frequently in en–gines used for electricity generating because the lower viscosity can be further reduced during the operation via oil dilution with fuel and this can cause the observable drop of oil pressure.

Table 2. The most important measured data was about the unused MT16P, MT, and ÖMV Panzer 20W50 lubricant sam–ples during the LubCheck analysis. (Source: Authors compilation)

Parameter	MT16P	MT	ÖMV Panzer
Kinematic viscosity on 40°C [mm^2/s]	139	45	178
Kinematic viscosity on 100°C [mm^2/s]	17.4	6.7	17.8
Ba content [mg/kg]	0	0	674
Ca content [mg/kg]	2920	966	4221
P content [mg/kg]	791	521	1047
Zn content [mg/kg]	993	614	1206
S content [mg/kg]	5399	3569	5658

Moreover, this can also be the reason why this MT lubricant is not used in these types of engines of military vehicles because an oil-changing process is much more challenging on the front line during an active military operation.

3.3 Analysing the plain bearings of the camshafts from this engine running as an electricity generator

A used camshaft bearing module was available for the authors to analyze what happens during the engine's operation. This camshaft bearing module worked inside an engine used for an electricity generator device which was operated with the previously introduced MT type of engine oil. This module is completely manufactured from aluminum alloy, even the bearing surface as well, while the camshafts are manufactured from iron alloy. Figure 6 shows the investigated camshaft bearing module and its bearing surfaces. The bearing surfaces were in a bad condition because a significant amount of wear could be identified without any microscopes: there is a vast wear groove in the middle area of the bearing surface (red marking in Figure 6.), and the whole bearing surface shows some interesting wear pattern, which should be further analyzed.

Figure 7 illustrates the acquired digital microscopic images of the bearing surface of this module and their location. The heavily damaged bearing surface was mainly analyzed (marked with a red ellipse in Figure 6), and two different wear pattern areas were identified there: the normal wear of this bearing surface is fatigue wear (Figure 7 A) and local but deep abrasive wear (Figure 7 B.). The fatigue wear could arise from the insufficient lubrication status of this bearing where the bearing surface experienced higher contact pressure and temperature, resulting in a network of cracks in the outer micrometer depth of the surface, and this led to a material removal of these weakened surface layers as microparticles. These microscopic wear particles usu–ally have higher hardness (because of self-hardening via contact temperature increase), and these particles could cause increased three-body abrasion wear on the surface [7], as is clearly visible in Figure 7 B).

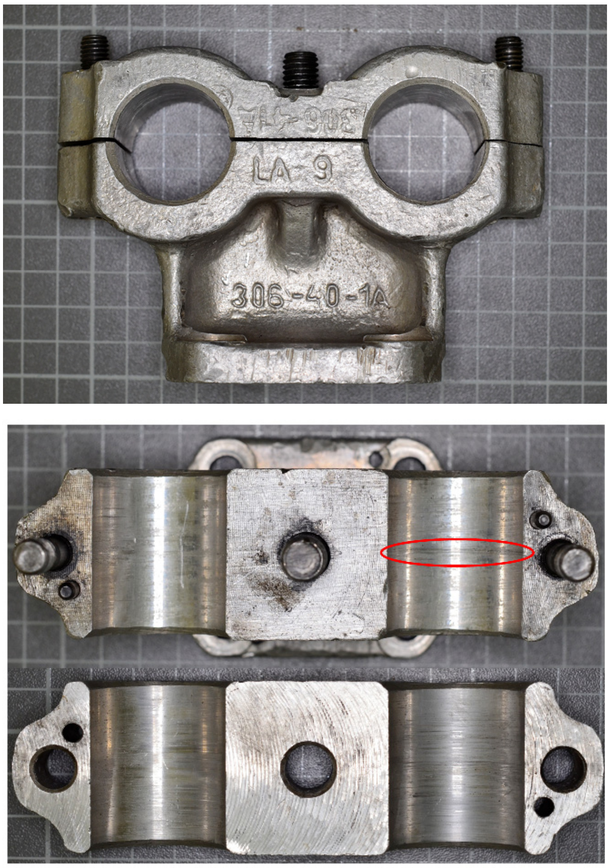

Figure 6. Camshaft bearing module and its bearing surfaces of the investigated V-6M engine type. (Source: Authors compilation)

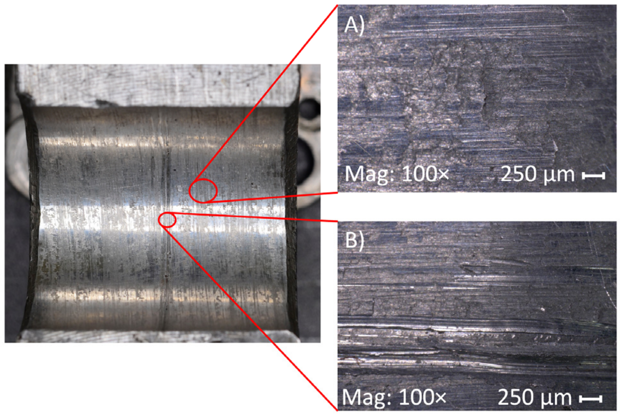

Figure 7. Digital microscopic images about the bearing surface of the investigated module were acquired with 100× magnitude. (Source: Authors compilation)

4. RESULTS AND DISCUSSION

As shown in this research, the application of the proper engine oil is vital to provide the engine with the desig–ned lifetime. The selection of proper lubricant for the engine, which is not supported anymore with its original lubricant, can be encouraged with this type of tribo–logical measurement and chemical oil analysis. How–ever, it can be a more time- and cost-consuming process to execute multiple measurements with a huge load-temperature matrix, and this measurement matrix can significantly be decreased with the usage of the Design of Experiment (DoE) method, similar to Sztankovics et al. who used this method in the case of investigating the honing machining processes of cylinder liner surfaces [15]. The number of experimental measurements can be decreased with this method by fitting a proper equation to some exact measurement points, and the function of the lubrication can be assumed on the non-measured points according to this fitted curve.

The result of this paper reveals and reinforces the necessity of continuous status control of engines and their components (both engine parts and lubricants) to ensure a proper application during operation including military and nonmilitary usage as well [16].

This article presents the executed investigation re–garding a V-6M-type engine and its lubrication vari–ations. We focused on identifying the differences bet–ween its used and unused samples and understanding why engine maintenance has to be carried out in the case of three variations of engine oils because the original type is not available anymore.

The tribological results of the used and unused variation of the original MT16P oil variation revealed that the depletion of the oil additives and the increase of oil contaminations decreases the protective layer on the contacting surfaces, resulting in a higher amount of abrasive wear under both testing temperatures. How–ever, the defined wear is still acceptable, but replacing the oil used in this engine is strongly recommended.

Three variations of unused engine oils were tested (MT16P, MT, and ÖMW Panzer 20W50), which are widely used in these types of engines. The MT16P was the original oil, but it has had to be replaced over the years because it is no longer available on the market. A significant difference was observed during the chemical analysis of the oil samples because the MT variation has significantly lower viscosity and contains fewer additive molecules compared to the original one and ÖMW Panzer, designed for highly loaded military applications. This difference could also be identified in the tribo–logical results (highly loaded contact surfaces during ball-on-disc tribotests with a higher amount of abrasive wear compared to the other variations).

The investigation of the bearing surfaces of a cam–shaft bearing module taken from a V-6M engine ope–rated as an electric generator (operated with the MT variation of engine oil) revealed an interesting pheno–menon: a significant amount of fatigue wear, including some deep abrasive grooves, is visible on the contacting surfaces and both wear mechanisms could be traced back to lubrication anomalies. This type of engine operated with MT oil variations can produce oil pressure drops during its operation (that is the reason why the engine oil should be replaced earlier in these engines), and this oil pressure drop can cause a high amount of fatigue wear, and three-body abrasion grooves as well.

One possible reason for this oil pressure drop was identified: the MT lubricant variation has significantly lower viscosity values at both lower and higher temperatures, which can be further decreased with fuel or cooling water contamination, which is, unfortunately, a normal phenomenon in the case of these engines because of the larger clearances between the engine components (an engine oil with lower visco–sity cannot form thick enough oil film for sealing purposes).

We determined that ÖMV Panzer is the most appro–priate one among the examined engine oils for the operation of V6-M type engines, we suggest this to be used in the electricity generator as well. Investigations proved that using MT-substituted lubricant can lead to engine damage. If there is no available recommended oil on the market, then tribological investigations of oils with the same parameters are recommended to be performed before choosing one.

5. CONCLUSION

The main scope of this paper is to highlight the challenges of the continuous operation of an older diesel engine. One of the key factors is the lubricant the engine is filled in with, where the biggest challenge is to find a currently available lubricant that is suitable for the given type of engine. The article reveals some of the crucial aspects of the lubricant-engine pair and some possible damages and failures that can happen in the case of a not properly chosen lubricant for the engine. Furt–hermore, the investigation revealed that the strongly used engine oil decreased the protection property of the lubricant itself and so the contacting surfaces suffered increased damage in the form of abrasion wear.

This type of investigation also reveals that a very thorough engine failure detection and prediction can be executed without disassembling the engine itself, which saves a significant amount of time and money for the owners.

This analysis proved the efficiency of the method because the increased aluminum content of the lubricant can arrive from the plain bearing surfaces of the camshafts and their bearing elements. The analysis also revealed that too low amount of viscosity does not provide sufficient protection and heat transfer in the lubrication areas and the results of this inadequate lubrication can be an increase in wear which can be escalated until the component is replaced to ensure the functionality of the engine.

In our opinion, the presented results can be well applied in engineering practice.

One possible future investigation can be the com–putational simulation and its application. With the help of calculation and simulation methods (e.g. Design of Experiment method), the maximal or minimal limits of each lubricant content can be calculated, and the nece–ssary engine renovations can be executed in time with a continuous analysis of oil samples using chemical and tribological methods.

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ИЗБОР МОТОРНИХ УЉА СА ТРИБОЛОШКИМ ИСПИТИВАЊИМА ПРИМЕНЉИВИХ НА СПЕЦИЈАЛНО УПРАВЉАНЕ ДИЗЕЛ МОТОРЕ

Р. Кути, Ф. Кенцел, Л. Чапо, Ч. Пап, Л. Фелди, А.Д. Тот

У новије време, многи специјално пројектовани дизел мотори произведени 1980-их се још увек користе у различитим областима, за које предложена моторна уља више нису доступна. Ови мотори поуздано раде у војним борбеним возилима, генераторима електричне енергије и гусеничарским машинама, тако да је неопходно испитати која моторна уља одговарају њиховим условима рада и могу се користити као њихово моторно уље. Циљ нашег истраживања је да се изврши триболошко испитивање узорка уља узетог из атмосферског дизел мотора типа В-6М и уља које је прописао произвођач. Након процене резултата, утврђујемо која врста уља је применљива у мотору да би се постигао сигуран рад и дуг животни век.