Society of Production
Engineering

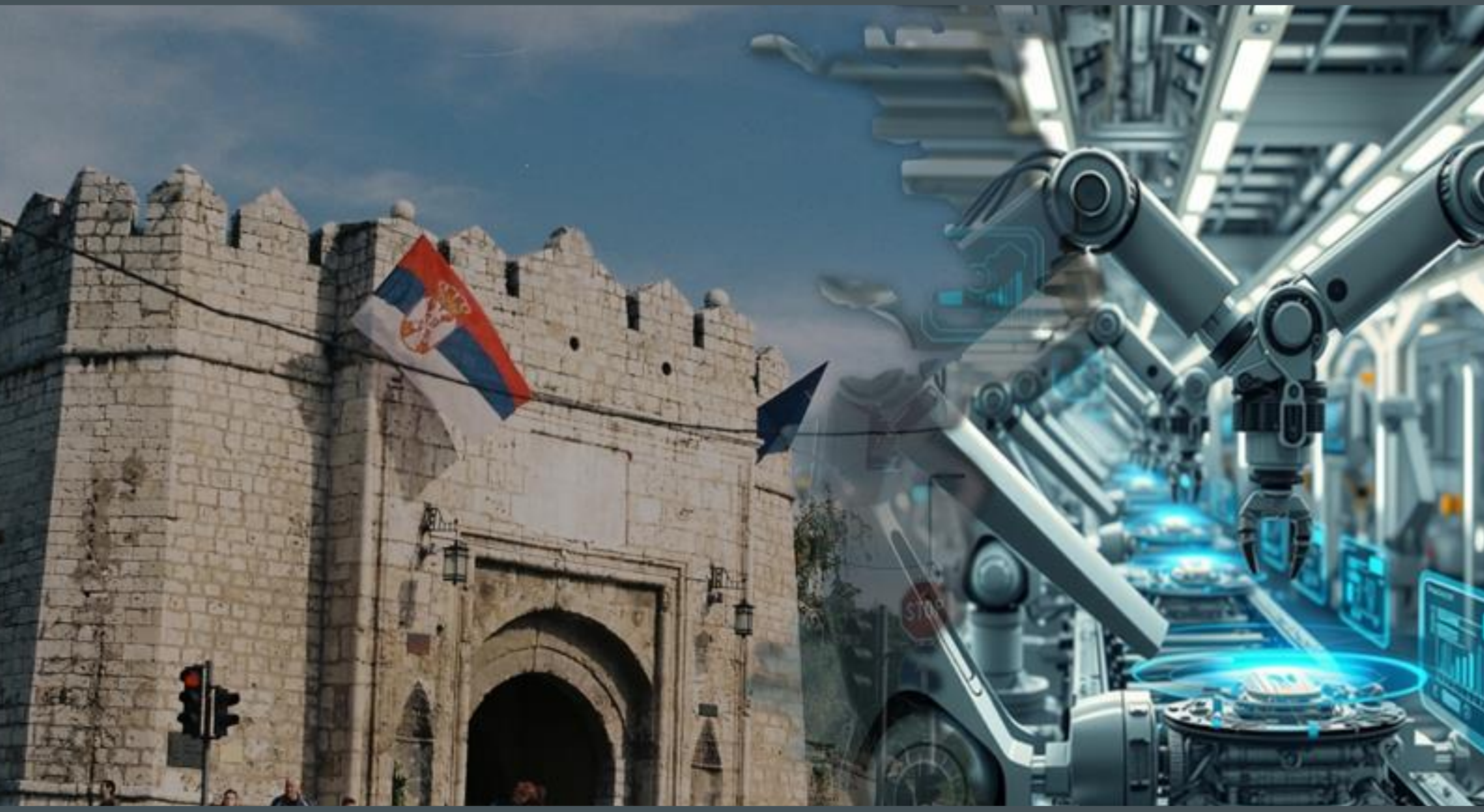
ICPES 2025

40th INTERNATIONAL CONFERENCE ON PRODUCTION ENGINEERING – SERBIA 2025

Nis, Serbia, 18th - 19th September 2025

University of Nis
Faculty of Mechanical
Engineering

CONFERENCE PROCEEDINGS



60th Anniversary of the Association of Production Engineering of Serbia

Editors:

Prof. dr Miodrag T. Manić, University of Niš, Faculty of Mechanical Engineering,

Prof. dr Saša S. Ranđelović, University of Niš, Faculty of Mechanical Engineering,

Publisher:

Faculty of Mechanical Engineering, Aleksandra Medvedeva 14, 18000 Niš, Serbia

For the Publisher:

Prof. dr Goran Janevski, Dean, University of Niš, Faculty of Mechanical Engineering,

Technical editor:

The Organizing Committee of ICPES2025

Cover design:

Ass. Rajko Turudija

Printing: Grafika Galeb , Niš

CIP - Каталогизација у публикацији
Народна библиотека Србије, Београд

621.7/.9(082)(0.034.2)
621.7/.9:669(082)(0.034.2)
681.5(082)(0.034.2)
005.6(082)(0.034.2)
004.896(082)(0.034.2)

INERNATIONAL Conference on Production Engineering (40 ; 2025 ; Niš)
Conference proceedings [Elektronski izvor] : 60th Anniversary of the Association of Production Engineering of Serbia / 40th International Conference of Production Engineering ICPES 2025 - Serbia 2025, Nis, Serbia, 18th - 19th September 2025 ; [organizer] The University of Niš, Faculty of Mechanical Engineering, Department for production and information technology ; [editors Miodrag T. Manić, Saša S. Ranđelović]. - Niš : Faculty of Mechanical Engineering, 2025 (Niš : Galeb). - 1 USB fleš memorija ; 1 x 1 x 6 cm

Sistemski zahtevi: Nisu navedeni. - Nasl. sa naslovne strane dokumenta. - Tiraž 100. - Foreword / Saša S. Ranđelović. - Bibliografija uz svaki rad.

ISBN 978-86-6055-197-1

a) Производно машинство -- Зборници b) Метали -- Обрада -- Зборници v) Системи аутоматског управљања -- Зборници g) Управљање квалитетом -- Зборници

COBISS.SR-ID 179507721

Financing of the Proceedings was sponsored by the Ministry of Education, Science and Technological Development of the Republic of Serbia.

The Association of Production Engineering of Serbia
UNIVERSITY OF NIŠ, Faculty of Mechanical Engineering

CONFERENCE PROCEEDINGS

40th INTERNATIONAL CONFERENCE ON PRODUCTION ENGINEERING SERBIA 2025

ICPES2025

Niš, September 2025

Organizing Institution:

The Association of Production Engineering of Serbia

Founders Institutions:

- Faculty of Mechanical Engineering, University of Belgrade, Department for production engineering, Serbia
- Faculty of technical science, University of Novi Sad, Department of production engineering, Serbia
- Faculty of Technical science, University of Novi Sad, Department of industrial engineering and management, Serbia
- Faculty of Mechanical Engineering, University of Niš, Department of production and information technology, Serbia
- Faculty of Technical sciences Čačak, University of Kragujevac, Department of mechatronic, Serbia
- Faculty of engineering science, University of Kragujevac, Department of production engineering, Kragujevac, Serbia
- Faculty of mechanical and civil engineering in Kraljevo, University of Kragujevac, Department of production engineering, Serbia
- Faculty of Technical science, Kosovska Mitrovica, University of Priština, Serbia
- LOLA institute, Belgrade, Serbia

Accompanied Institutions:

- Faculty of Mechanical engineering, Podgorica, University of Montenegro, Montenegro
- Faculty of Production and management Trebinje, University of East Sarajevo, Bosnia and Hercegovina
- Faculty of Mechanical engineering, Banja Luka, University of Banja Luka, Department of production and computer aided technology, Bosnia and Hercegovina
- Faculty of Mechanical engineering, University of East Sarajevo, Bosnia and Hercegovina
- Polytechnic faculty, University of Zenica, Bosnia and Hercegovina
- Faculty of Mechanical engineering, University of Skopje, North Macedonia
- Technical faculty Bitola, University saint Kliment Ohridski, North Macedonia
- Technical faculty Mihajlo Pupin, Zrenjanin, University of Novi Sad, Serbia
- Technical faculty, Department of mechanical engineering, University of Bihać, Bosnia and Hercegovina
- Technical faculty Bor, University of Belgrade
- Academy of Professional Studies SUMADIJA, Department of mechanical and industrial engineering, Serbia

ORGANIZER:

THE UNIVERSITY OF NIŠ, Faculty of Mechanical Engineering,

Department for production and information technology

www: masfak.ni.ac.rs, **e mail:** icpespms25@gmail.com

Hotel Cristal Light, Niš

International Scientific Committee

President:

dr Miodrag Manić, University of Niš, Faculty of Mechanical Engineering, Serbia

Memebers:

dr Aco Antić, University of Novi Sad, Serbia
dr Zoran Miljković, University of Belgrade, Serbia
dr Živana Jakovljević, University of Belgrade, Serbia
dr Saša Živanović, University of Belgrade, Serbia
dr Dragan Đurđanović, University Austin, USA
dr Dejan Lukić, University of Novi Sad, Serbia
dr Radovan Puzović, University of Belgrade, Serbia
dr Ilija Ćosić, University of Novi Sad, Serbia
dr Filip Gorski, University Poznan, Poland
dr Sebastian Baloš, University of Novi Sad, Serbia
dr Milenko Sekulić, University of Novi Sad, Serbia
dr Georg Weichhart, Primetals, Austria
dr Slobodan Tabaković, University of Novi Sad, Serbia
dr Branko Škorić, University of Novi Sad, Serbia
dr Miodrag Hadžistević, University of Novi Sad, Serbia
dr Đorđe Vukelić, University of Novi Sad, Serbia
dr Igor Budak, University of Novi Sad, Serbia
dr Bojan Lalić, University of Novi Sad, Serbia
dr Razvan Pacurar, University Cluj-Napoca, Romania
dr Mijodrag Milošević, University of Novi Sad, Serbia
dr Samir Lemeš, University of Zenica, B&H
dr Obrad Spaić, University of East Sarajevo, B&H
dr Radoslav Vučurević, University of East Sarajevo, B&H
dr Milija Kraišnik, University of East Sarajevo, B&H
dr Aleksandar Košarac, University of East Sarajevo, B&H
dr Stojanče Nusev, University Bitola, North Macedonia
dr Damir Hodžić, University of Bihać, B&H
dr Sanel Gredelj, University of Bihać, B&H
dr Branislav Sredanović, University of Banja Luka, B&H
dr Mileta Janjić, University of Podgorica, MNG
dr Radmil Polenakovikj, University Sv.Ki.Me., N Macedonia
dr Dejan Tanikić, University of Belgrade, Serbia
dr Saša S. Ranđelović, University of Niš, Serbia
dr Predrag Janković, University of Niš, Serbia
dr Vladislav Blagojević, University of Niš, Serbia
dr Miloš Stojković, University of Niš, Serbia
dr Nikola Korunović, University of Niš, Serbia
dr Milan Zdravković, University of Niš, Serbia
dr Nikola Vitković, University of Niš, Serbia
dr Jelena Stojković, University of Niš, Serbia
dr Milan Trifunović, University of Niš, Serbia
dr Miloš Madić, University of Niš, Serbia
dr Santiago C. Gutiérrez, University of Valencia, Spain
dr Solano G. Lorenzo, University of Valencia, Spain
dr Dragan Adamović, Unive of Kragujevac, Serbia
dr Goran Devedžić, University of Kragujevac, Serbia
dr Milan Erić, University of Kragujevac, Serbia
dr Branko Radičević, University of Kragujevac, Serbia
dr Mirko Đapić, University of Kragujevac, Serbia
dr Snežana Dragićević, University of Kragujevac, Serbia
dr Jasmina Vesić-Vasović, University of Kragujevac, Serbia
dr Miladin Stefanović, University of Kragujevac, Serbia
dr Maja Trstenjak, University of Zagreb, Croatia
dr Vojislav Petrović Filipović, FH Wiener Neustadt, Austria
dr Fernando G. Warchomicka, University of Graz, Austria
dr Bojan Ačko, University of Maribor, Slovenia
dr Biserka Runje, University of Zagreb, Croatia
dr Pilar Rey Rodriguez, Technology center AIMEN, Spain
dr Srećko Manasijević, LOLA Institute, Serbia
dr Lazar Kovačević, University of Novi Sad, Serbia
dr Nenad Simeunović, University of Novi Sad, Serbia
dr Ivan Milićević, University of Kragujevac, Serbia
dr Ognjan Lužanin, University of Novi Sad, Serbia
dr Mihajlo Popović, University of Belgrade, Serbia
dr Nikola Slavković, University of Belgrade, Serbia
dr Slavenko Stojadinović, University of Belgrade, Serbia
dr Goran Miladinović, University of Belgrade, Serbia
dr Branko Kokotović, University of Belgrade, Serbia
dr Milica Petrović, University of Belgrade, Serbia
dr Mladomir Milutinović, Unive of Novi Sad, Serbia
dr Tomaž Pepelnjak, Unive of Ljubljana, Slovenia
dr Davorin Kramar, University of Ljubljana, Slovenia
dr Đorđe Čiča, University of Banja Luka, B&H
dr Stevo Borojević, University of Banja Luka, B&H
dr Sven Maričić, Unive of Juraj Dobrila in Pula, Croatia
dr Slobodan Mitrović, Unive of Kragujevac, Serbia
dr Srećko Čurčić, Unive of Kragujevac, Serbia
dr Zoran Dimić, LOLA Institute, Serbia

Honorary Committee

dr Milisav Kalajdžić, University of Belgrade, Serbia
dr Pavao Bojanić, University of Belgrade, Serbia
dr Dragan Milutinović, University of Belgrade, Serbia
dr Miroslav Pilipović, University of Belgrade, Serbia
dr Miloš Glavonjić, University of Belgrade, Serbia
dr Petar Petrović, University of Belgrade, Serbia
dr Velimir Todić, University of Novi Sad, Serbia
dr Dragoje Milikić, University of Novi Sad, Serbia
dr Bogdan Sovilj, University of Novi Sad, Serbia
dr Velimir Todić, University of Novi Sad, Serbia
dr Bogdan Nedić, University of Kragujevac, Serbia
dr Goran Putnik, University Minho, Portugal
dr Velibor Marinković, University of Niš, Serbia
dr Dragan Domazet, University of Niš, Serbia
dr Dragan Temeljkovski, University of Niš, Serbia
dr Tihomir Pantelić, University of Kragujevac, Serbia
dr Ratomir Ječmenica, University of Kragujevac, Serbia
dr Snežana Radonjić, University of Kragujevac, Serbia
dr Miomir Vukićević, University of Kragujevac, Serbia
dr Dragiša Vilotić, University of Novi Sad, Serbia
dr Miroslav Plančak, University of Novi Sad, Serbia
dr Miodrag Lazić, University of Kragujevac, Serbia
dr Milentije Stefanović, University of Kragujevac, Serbia
dr Ratko Mitrović, University of Kragujevac, Serbia
dr Slavko Arsovski, University of Kragujevac, Serbia
dr Branislav Jeremić, University of Kragujevac, Serbia
dr Ljubodrag Tanović, University of Belgrade, Serbia
dr Ljubomir Lukić, University of Kragujevac, Serbia
dr Vidosav Majstorović, University of Belgrade, Serbia
dr Pavel Kovač, University of Novi Sad, Serbia
dr Marin Gostimirović, University of Novi Sad, Serbia
dr Svetislav Dekić, University of Pristina, Serbia
dr Vid Jovišević, University Banja Luka
dr Milan Zeljković, University of Novi Sad, Serbia
dr Miroslav Radovanović, University of Niš, Serbia
dr Vladimir Kvrgić, Mihajlo Pupin Institute, Serbia
dr Slavica Cvetković, University of Pristina, Serbia

Organizing Committee

President:

dr Saša S. Ranđelović, University of Niš, Faculty of Mechanical Engineering, Serbia

Memebers:

dr Miloš Simonović, University of Niš, Serbia
dr Dušan Petković, University of Niš, Serbia
dr Miloš Tasić, University of Niš, Serbia
M.Sc. Rajko Turudija, University of Niš, Serbia
M.Sc. Jovan Aranđelović, University of Niš, Serbia
M.Sc. Vladimir Mitrović, University of Niš, Serbia
M.Sc. Aleksandar Trajković, University of Niš, Serbia
M.Sc. Dejan Žikić, University of Niš, Serbia

ORGANIZERS OF THE CONFERENCE ON PRODUCTION ENGINEERING OF SERBIA

from 1965 to 2025

No.	Place	Year	No.	Place	Year
I	Beograd	1965	XXI	Opatija	1987
II	Zagreb	1966	XXII	Ohrid	1989
III	Ljubljana	1967	XXIII	Zagreb	1991 (not perform)
IV	Sarajevo .	1968	XXIV	Novi Sad	1992
V	Kragujevac	1969	XXV	Beograd	1994
VI	Opatija	1970	XXVI	Podgorica	1996
VII	Novi Sad.	1971	**XXVII**	**Niš**	**1998**
VIII	Ljubljana	1973	XXVIII	Kraljevo	2000
IX	**Niš**	**1974**	XXIX	Beograd	2002
X	Beograd	1975	XXX	Čačak	2005
XI	Ohrid	1977	XXXI	Kragujevac	2006
XII	Maribor	1978	XXXII	Novi Sad	2008
XIII	Banja Luka	1979	XXXIII	Beograd	2009
XIV	Čačak	1980	**XXXIV**	**Niš**	**2011**
XV	Novi Sad	1981	XXXV	Kraljevo	2013
XVI	Mostar	1982	XXXVI	Beograd	2015
XVII	Budva	1983	XXXVII	Kragujevac	2018
XVIII	**Niš**	**1984**	XXXVIII	Čačak	2021
XIX	Kragujevac	1985	XXXIX	Novi Sad	2023
XX	Beograd	1986	**XL**	**Niš**	**2025**

Table of Contents

Society of Production Engineering

ICPES 2025

40th INTERNATIONAL CONFERENCE ON PRODUCTION ENGINEERING - SERBIA 2025

DOI: 10.46793/ICPES25.178D

University of Nis
Faculty of Mechanical Engineering

Nis, Serbia, 18 - 19th September 2025

A COMPARATIVE STUDY ON THE TRIBOLOGICAL BEHAVIOR OF NEW AND USED 10W-40 ENGINE OIL APPLIED IN GASOLINE AND DIESEL ENGINES

Dragan DZUNIC[1], Vladimir KOCOVIC[1], Zivana JOVANOVIC PESIC[1, *], Slobodan MITROVIC[1], Milan ERIC[1]

Orcid: 0000-0002-1914-1298; **Orcid:** 0000-0002-1373-0040; **Orcid:** 0000-0001-8691-4863;

[1] University of Kragujevac, Faculty of Engineering, Kragujevac, Republic of Serbia

*Corresponding author: zixi90@gmail.com

Abstract: *This study presents a comparative analysis of the tribological behaviour of new and used SAE 10W-40 engine oil, collected from gasoline and diesel passenger car engines and tested under cold-start conditions. The investigation examined the influence of oil aging and engine type on viscosity, friction, and wear. Block-on-disc experiments were performed using aluminium (EN AW-6060) against hardened steel (EN 25CrMo4) following ASTM G77 procedures. The results showed that used oils exhibited lower coefficients of friction and smaller wear scars compared to new oil. The diesel-derived sample achieved the best performance, with the lowest steady-state friction and wear volume, likely due to degradation products and fuel residues that enhanced boundary lubrication. Although used oils displayed improved short-term tribological behaviour, their long-term performance in actual engines is limited by oxidation, contamination, and corrosiveness. These findings provide insights into lubricant degradation and may support the optimization of oil-change intervals and the development of improved multigrade oils.*

Keywords: *Tribology, engine oil, Cold-start conditions, Wear scar analysis, Gasoline and diesel engines*

1. INTRODUCTION

The application of aluminium in internal combustion engine construction has become increasingly widespread, particularly in the manufacture of sliding bearings, pistons, and connecting rods. This material offers several advantages, including low specific weight, high corrosion resistance, favorable thermal conductivity, recyclability, and a measurable contribution to improved fuel economy. Nevertheless, its relatively limited wear resistance and certain mechanical constraints necessitate careful consideration of surface protection, with engine oil quality playing a decisive role in ensuring reliability and durability [1].

The performance of engine oil exerts a profound and multifaceted influence on the wear behaviour of aluminium surfaces. Wear represents one of the principal mechanisms of material degradation in engine blocks, and its progression is governed by several factors: the presence of hard particles and chemical contaminants in cooling and lubricating fluids promotes abrasive and corrosive wear; exposure to high-temperature gases contributes to erosive wear; frictional interaction between the cylinder wall and piston rings may induce adhesive wear even under lubricated conditions; and material fatigue further accelerates deterioration. High-quality engine oils mitigate these effects by reducing friction, maintaining optimal viscosity, and incorporating additive packages designed to protect aluminium components against wear and corrosion [2,3].

The SAE 10W-40 multigrade engine oil is among the most commonly applied lubricants in passenger car engines, primarily due to its capacity to maintain reliable performance across a wide range of operating temperatures. The “10W” designation reflects its ability to ensure adequate fluidity and lubrication during cold starts, whereas the “40” grade denotes sufficient viscosity retention at elevated thermal and mechanical loads. Such versatility enables 10W-40 oils to provide both start-up protection and long-term durability under diverse service conditions. Their formulations typically combine refined base oils with advanced additive packages, which collectively enhance viscosity stability, reduce friction and wear, and safeguard components from corrosion and deposit formation. Furthermore, recent studies have demonstrated that the incorporation of graphene–cellulose nanocomposites into 10W-40 oil can further improve its thermophysical and tribological performance, yielding a lower coefficient of friction and superior wear resistance, thereby extending the protective capabilities of this lubricant [4].

During service, engine oil inevitably undergoes degradation as a consequence of prolonged exposure to elevated temperatures, mechanical stresses, and by-products of fuel combustion. These processes manifest through visible changes such as darkening of the oil, loss of transparency, and the development of an unpleasant odour, which are commonly recognized as the first signs of oil aging and contamination. Among the resulting alterations, variations in kinematic viscosity are of particular importance. A reduction in viscosity leads to decreased oil pressure and insufficient film strength, thereby increasing friction and accelerating the wear of critical engine components such as piston rings and bearings. Conversely, an excessive rise in viscosity compromises oil circulation and impedes the stable formation of a lubricating film at tribological contact surfaces [5–7].

Recycling of used engine oils is an essential strategy for sustainable resource utilization, environmental protection, and the mitigation of ecological hazards arising from toxic compounds contained in spent lubricants. The recycling of SAE 10W-40 engine oil poses particular challenges due to its complex chemical composition and the accumulation of contaminants during engine operation. Additive packages and chemical constituents undergo significant transformations under thermal and mechanical stress, generating harmful by-products that require advanced refining or re-refining technologies. Recent industrial advances, such as the development of Quartz EV3R 10W-40 by Total Energies, have demonstrated the feasibility of producing high-performance lubricants entirely from re-refined base oils, achieving up to a 46% reduction in wear and a 20% improvement in piston cleanliness compared to conventional oils [8]. Complementary academic studies have also provided promising results: Jurny et al. reported that solvent extraction using N-methyl-2-pyrrolidone enabled the recovery of approximately 10 L of reusable base oil from 25 L of used lubricant, thereby significantly reducing dependence on virgin crude oil for base stock production [9].

In this study, a comparative tribological analysis was carried out on new and used SAE 10W-40 engine oil after operation in gasoline and diesel passenger car engines. The investigation was performed under cold-start conditions, with the objective of assessing how oil aging and engine type influence viscosity changes, frictional response, and wear protection. By examining both new and used oils, the study highlights the degradation mechanisms of 10W-40 under distinct combustion regimes and start-up stresses, thereby providing valuable insight into lubricant performance in real-world applications.

2. MATERIALS AND METHOD

This study investigated the tribological performance of SAE 10W-40 multigrade engine oil in both new and used conditions. New oil was tested as a reference to establish its baseline tribological properties, while used oil samples were collected after extended operation in gasoline and diesel passenger car engines. In service, the oil undergoes significant physicochemical changes, including variations in viscosity, darkening of colour, and accumulation of combustion by-products, all of which can directly influence its lubricating efficiency. The 10W-40 grade was selected because of its widespread application in passenger cars, providing adequate lubrication at low temperatures ("10W") while maintaining sufficient viscosity at elevated thermal and mechanical loads ("40").

Experimental testing was carried out using a TPD-95 block-on-disc tribometer, equipped with computer-controlled precision to ensure stable and repeatable operating conditions, in accordance with the ASTM G77 standard. In this configuration, an aluminium block (EN AW-6060 alloy) was pressed against a rotating hardened steel disc (EN 25CrMo4, 60–64 HRC, ground finish, Ø 35 mm), effectively replicating sliding contact conditions representative of real engine components. The aluminium blocks were prepared following a standardized surface treatment: sequential grinding at 500 rpm for 1 minute per side using progressively finer silicon carbide abrasive papers (P600, P1200, and P2000). This preparation ensured uniform surface conditions across all samples, which is essential for experimental reliability.

The tribological tests were performed under identical operating parameters: a normal load of 20 daN, a sliding speed of 0.5 m/s, and a total sliding duration of 600 seconds. Continuous lubrication during testing was provided by a reservoir system (30 ml capacity), ensuring a stable supply of oil at the contact interface. Under these conditions, three sets of experiments were defined: new 10W-40 oil, used 10W-40 oil collected from a gasoline engine, and used 10W-40 oil collected from a diesel engine.

The volume of worn material was calculated analytically using the following expression:

$$V=\left(\frac{306.25}{2}\cdot 2arcsin\left(\frac{b}{35}\right)-\frac{\sqrt{306.25-\frac{b^2}{4}}\cdot b}{2}\right)\cdot 6.35 \quad (1)$$

where b is the width of the wear mark (mm), 306.25 is the square of the disc radius, and 6.35 mm represents the block width. This equation accounts for the geometry of the block-on-disc contact and enables accurate estimation of volumetric wear based on the measured scar dimensions.

3. RESULTS AND DISCUSION

Figure 1 shows the variation of the coefficient of friction (μ) as a function of sliding distance for new SAE 10W-40 oil, as well as for used oil collected from diesel and gasoline engines.

At the beginning of the test, all samples exhibited relatively high friction values due to the absence of a fully established lubricating film. For the new 10W-40 oil (AL-10W-40-N), the coefficient of friction started at approximately 0.05–0.055 and gradually decreased to a stable level of around 0.02 after about 100 m of sliding. This behaviour reflects the running-in process, during which the oil film progressively formed and stabilized the contact conditions.

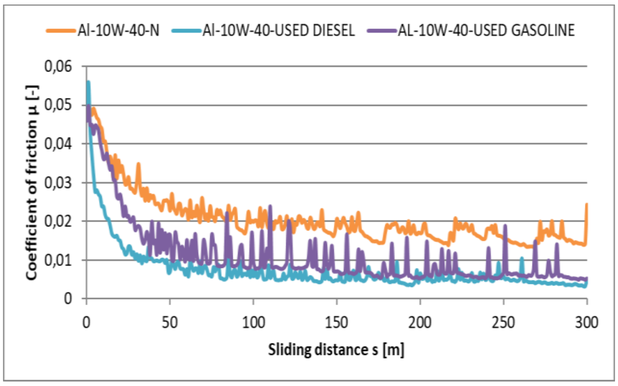


Figure 1. Coefficient of friction versus sliding distance for new and used SAE 10W-40 engine oils

In contrast, the used oil samples demonstrated improved frictional behaviour. The oil collected from the diesel engine (AL-10W-40-USED DIESEL) exhibited the lowest steady-state friction, stabilizing below 0.01 after the initial running-in stage. This may be attributed to chemical and physical changes in the oil during operation, including the presence of degradation products and fuel residues, which could enhance boundary lubrication properties under the given test conditions.

The used gasoline engine oil (AL-10W-40-USED GASOLINE) showed intermediate behaviour. While the initial friction values were comparable to those of the new oil, the coefficient of friction decreased more rapidly and reached values close to those of the used diesel oil. However, the curve exhibited more pronounced fluctuations, which may indicate less stable lubricating film formation, possibly due to differences in contamination mechanisms between gasoline and diesel combustion.

Table 1 presents the average wear scar width and the corresponding calculated wear volume for aluminium samples lubricated with new and used SAE 10W-40 engine oils. The values represent the mean of multiple measurements for each test group, ensuring statistical reliability.

The results indicate a consistent trend of reduced wear in the presence of used engine oils compared to new oil. The new 10W-40 oil produced the largest average wear scar (2.643 mm) and the highest wear volume (0.559 mm^3), reflecting the oil's baseline tribological behaviour in the absence of degradation products. In contrast, the used oils exhibited smaller wear scars and correspondingly lower wear volumes, with 2.300 mm (0.368 mm^3) for the gasoline engine sample and 2.000 mm (0.242 mm^3) for the diesel engine sample.

Table 1. Average wear scar width and wear volume of aluminium samples lubricated with SAE 10W-40 engine oils

Sample	Wear scar width, b (mm)	Wear volume (mm^3)
AL-10W-40-N (New Oil)	2.643	0.559
AL-10W-40-USED GASOLINE	2.300	0.368
AL-10W-40-USED DIESEL	2.000	0.242

The reduced wear observed with used oils can be attributed to chemical and physical transformations occurring during engine operation. Degradation products, fuel residues, and oxidized compounds may act as additional boundary lubricants, temporarily improving the oil's ability to form protective films on aluminium surfaces. Among the tested samples, the diesel-derived oil showed the lowest wear scar and wear volume, which is consistent with its lower steady-state coefficient of friction (Figure 1), suggesting more stable boundary film formation under the applied test conditions.

Nevertheless, it must be emphasized that although used oils may demonstrate improved short-term tribological behaviour in laboratory block-on-disc testing, their long-term protective performance in actual engine operation is adversely affected by oxidation, contamination, and increased corrosiveness. This dual effect highlights the necessity of carefully balancing lubricant degradation and protective efficiency when evaluating oil performance in real applications.

4. CONCLUSION

This study investigated the tribological behaviour of new and used SAE 10W-40 engine oil, with samples obtained from both gasoline and diesel passenger car engines and tested under cold-start conditions. The findings highlight the influence of oil degradation and engine type on viscosity, frictional behaviour, and wear protection.

The results demonstrated that used oils exhibited lower coefficients of friction and reduced wear scar dimensions compared to new oil. The diesel-derived oil, in particular, achieved the lowest steady-state friction values and the smallest wear volume, suggesting the formation of a more stable boundary film. This behaviour is most likely associated with the presence of degradation products and fuel-derived compounds that temporarily enhance lubrication under boundary contact conditions.

However, despite these short-term improvements observed in laboratory testing, it must be emphasized that prolonged use of aged oils in engines is not beneficial. Chemical degradation, contamination, and increased corrosiveness compromise the long-term protective performance of lubricants. The insights gained from this comparative study contribute to a deeper understanding of oil degradation mechanisms and may support the optimization of oil-change intervals, lubricant formulation strategies, and improved protection of aluminium-based engine components.

ACKNOWLEDGEMENT

This paper is the result of research conducted under the author’s contract No. 451-03-137/2025-03/200107, dated February 4, 2025, and supported by the Ministry of Science, Technological Development and Innovation, Republic of Serbia.

REFERENCES

[1] Z. Aleš, J. Pavlů, J. Svobodová, M. Kučera, M. Hromasová, M. Pexa: Impact of contaminants in motor oil on the wear of aluminum parts of the internal combustion engine, Manufacturing Technology, Vol. 17, No. 5, pp. 647-652, 2017.

[2] M.S. Kaiser, S. Dutta: Wear behavior of commercial aluminium engine block and piston under dry sliding condition, International Journal of Materials and Metallurgical Engineering, Vol. 8, No. 8, pp. 860-865, 2014.

[3] S. Rațiu, A. Josan, V. Alexa, V.G. Cioată, I. Kiss: Impact of contaminants on engine oil: A review, Journal of Physics: Conference Series, Vol. 1781, p. 012051, 2021.

[4] J.G. Alotaibi, et al.: Enhancing engine oil performance with graphene-cellulose nanoparticles: insights into thermophysical properties and tribological behavior, Frontiers in Materials, Vol. 12, p. 1549117, 2025.

[5] K. Sakamoto, F. Mizutani, M. Shimomura, K. Yama, T. Matsunaga, S.-S. Lee: Evaluation of engine oil degradation based on viscosity and transmitted light intensity measurements, Sensors and Actuators A: Physical, Vol. 361, p. 114597, 2023.

[6] R. Smigins, K. Amatnieks, A. Birkavs, K. Górski, S. Kryshtopa: Studies on engine oil degradation characteristics in a field test with passenger cars, Energies, Vol. 16, p. 7955, 2023.

[7] Y.N. Bezborodov, N.N. Lysyannikova, E.G. Kravcova: Results of the study of anti-wear properties of the exhaust motor oil, Procedia Engineering, Vol. 150, pp. 654-660, 2016.

[8] Total Energies Lubrifiants, Stellantis: Quartz EV3R 10W-40 – a 100% re-refined engine lubricant with reduced wear and improved cleanliness, 2024

[9] M. Jurny, M. Elbourawi, E. Zorgani: Recycling of used engine oil using extraction by single solvent, American Journal of Chemical Engineering, Vol. 11, No. 2, pp. 33-38, 2023.