



Faculty of Engineering
University of Kragujevac



Ministry of Science, Technological
Development and Innovation

**11th International Congress
Motor Vehicles & Motors 2026
ECOLOGY -
VEHICLE AND ROAD SAFETY
- EFFICIENCY
Proceedings**



University of Kragujevac



Department for Motor Vehicles
and Motors



International Journal for Vehicle
Mechanics, Engines and
Transportation Systems

October 8th - 9th, 2026
Kragujevac, Serbia

**11th International Congress
Motor Vehicles & Motors 2026**

**ECOLOGY -
VEHICLE AND ROAD SAFETY
- EFFICIENCY**

BOOK OF PROCEEDINGS

October 8th - 9th, 2026
Kragujevac, Serbia

Publisher: The Faculty of Engineering of the University of Kragujevac
Serbia, 34000 Kragujevac, Sestre Janjić 6

For Publisher: Prof. Slobodan Savić, Ph.D.
Dean of the Faculty of Engineering

Editors: Prof. Danijela Miloradović, Ph.D.
Assist. prof. Nadica Stojanović, Ph.D.
The Faculty of Engineering of the University of Kragujevac

Technical preparation: Asisst. Prof. Nadica Stojanović, Ph.D.

Cover: Nemanja Lazarević

USB edition: Faculty of Engineering, University of Kragujevac, Kragujevac

ISBN: 978-86-6335-132-5

Year of publication: 2026.

Published on USB by: InterPrint
Aleksinačka St. nn, 34000 Kragujevac, Serbia

Number of copies: 100

CIP - Каталогизacija y yбликацији Народна библиотека Србије, Београд

629.3(082)(0.034.2)
621.43(082)(0.034.2)

INTERNATIONAL Congress Motor Vehicles & Motors (11 ; 2026 ; Kragujevac)

Ecology - Vehicle and Road Safety - Efficiency [Elektronski izvor] : proceedings
/ 11th international congress Motor vehicles & motors 2026, October 8th - 9th,
2026 Kragujevac, Serbia ; [editors Danijela Miloradović, Nadica Stojanović]. -
Kragujevac : University, Faculty of Engineering, 2026 (Kragujevac : InterPrint). -
1 USB fleš memorija ; 1 x 2 x 6 cm

Sistemska zahtevi: Nisu navedeni. - Nasl. sa nasl. strane dokumenta. - Tiraž 100.
- Bibliografija uz svaki rad.

ISBN 978-86-6335-132-5

a) Моторна возила – Зборници b) Моторни са унутрашњим сагоревањем -
- Зборници

COBISS.SR-ID 201905929

*Publishing of this USB Book of proceedings was supported by
Ministry of Science, Technological Development and Innovation of the Republic of Serbia*

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FOREWORD

For 47 years, a traditional international gathering - originally known as a Symposium and, since 2006, as the "Motor Vehicles and Motors" Congress - has been held biennially at the Faculty of Engineering (formerly the Faculty of Mechanical Engineering) of the University of Kragujevac. This year, the 11th International Congress "Motor Vehicles and Motors" took place in Kragujevac on October 8th–9th, 2026, under the traditional motto: "Ecology – Vehicle and Road Safety – Efficiency".

A large number of authors from both the country and abroad responded to the organizers' invitation, resulting in numerous high-quality submissions across the event's core areas: "Power Train Technology," "Vehicle Design and Manufacturing," "Vehicle Dynamics and Intelligent Control Systems," "Driver/Vehicle Interface, Information Systems, and Assistance Systems," and "Transport Challenges in Emerging Economies." Additionally, two topics were officially introduced for the first time: "Artificial Intelligence in Automotive Technology" and "Autonomous Vehicles".

A total of 63 papers were accepted for presentation following a rigorous peer-review process. The presentations were organized into sessions, including a newly introduced poster session dedicated to students and young researchers.

The Congress organizers extend their special gratitude to the distinguished scientists in the fields of motor vehicles and transportation who agreed to deliver three inspiring introductory lectures addressing the heart of contemporary issues in the sector: prof. dr Ralph Putz (Landshut University of Applied Sciences, Germany), prof. dr Aleksandar Stevanović (University of Pittsburgh, USA), and prof. dr. Isak Karabegović (Academy of Sciences and Arts of Bosnia and Herzegovina, Bosnia and Herzegovina).

We extend our sincere gratitude to the esteemed members of the Congress Scientific Committee—who also served as reviewers for the papers submitted for presentation—for their significant contribution to the overall quality of the accepted papers.

The organization of the Congress was once again supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, the Faculty of Engineering of the University of Kragujevac, and the International journal "Mobility & Vehicle Mechanics" and we sincerely thank them for their support.

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PREDGOVOR

Već 47 godina, svake druge godine, na Fakultetu inženjerskih nauka (nekada Mašinskom fakultetu) Univerziteta u Kragujevcu održava se tradicionalan međunarodni skup, nekada nazivan Simpozijum, a od 2006. godine - Kongres „Motorna vozila i motori“. Ovogodišnji, 11. Međunarodni kongres „Motorna vozila i motori“ održan je u Kragujevcu od 8. do 9. oktobra 2026. godine, uz tradicionalni moto „Ekologija – Vozilo i bezbednost na putu – Efikasnost“.

Na poziv organizatora odazvao se veliki broj autora iz zemlje i inostranstva, što je donelo veliki broj prijavljenih kvalitetnih radova iz glavnih oblasti skupa: „Tehnologija pogonskog sistema“, „Dizajn i proizvodnja vozila“, „Dinamika vozila i inteligentni upravljački sistemi“, „Interfejs vozač/vozilo, informacioni sistemi i sistemi za pomoć“, „Transportni izazovi ekonomija u usponu“, uz prvi put zvanično promovisane teme – „Veštačka inteligencija u automobilskoj tehnologiji“ i „Autonomna vozila“.

Ukupan broj od 63 radova je prihvaćen za prezentaciju posle rigoroznog procesa recenziranja. Rad je organizovan po sekcijama, uz prvi put promovisanu poster sekciju namenjenu za studente i mlade istraživače.

Organizatori Kongresa su posebno zahvalni istaknutim naučnicima iz oblasti motornih vozila i saobraćaja koji su pristali da održe tri inspirativna uvodna predavanja koja zadiru u srž savremenih pitanja vezana za vozila i saobraćaj, a to su: prof. dr Ralph Putz (Landshut University of Applied Sciences, Nemačka), prof. dr Aleksandar Stevanović (University of Pittsburgh, SAD) i prof. dr Isak Karabegović (Akademija nauka i umjetnosti Bosne i Hercegovine, Bosna i Hercegovina).

Veliku zahvalnost dugujemo našim dragim članovima Naučnog odbora Kongresa, ujedno i recenzentima radova prijavljenih za prezentaciju na Kongresu, koji su mnogo doprineli ukupnom kvalitetu konačno prihvaćenih radova.

Organizaciju Kongresa i ovog puta su podržali: Ministarstvo nauke, tehnološkog razvoja i inovacija Republike Srbije, Fakultet inženjerskih nauka Univeziteta u Kragujevcu i Međunarodni časopis „Mobility & Vehicle Mechanics“, na čemu im se iskreno zahvaljujemo.

Naučni odbor i Organizacioni odbor Kongresa MVM2026

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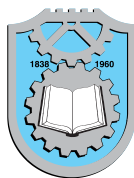
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The 11th International Congress
Motor Vehicles & Motors 2026
Kragujevac, Serbia
October 8th - 9th, 2026



MVM2026-003

<https://doi.org/10.24874/CMVM2026.003>

Original scientific paper

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THE INVESTIGATION OF THE COMBUSTION PROCESS OF THE BLEND OF THE CONVENTIONAL DIESEL FUEL AND BIODIESEL MADE FROM THE WASTE GRAPE SEEDS

ABSTRACT: The fact that the oil crisis happens around the world, the alternatives for the conventional diesel fuel can be considered as the future solution. the best option for the biodiesel production, is to produce it from the waste. In this way, the production doesn't affect on the food production, even more, the potential waste can be used for something useful. In the paper is conducted the experimental analysis of the combustion process of the blend made from conventional diesel fuel and biodiesel fuel made from waste grape seeds. The proportion of the investigated blend is the 86 %vol of the diesel fuel and 14 %vol of the biodiesel fuel. All results were compared to the combustion process when diesel fuel is used as only fuel. On the basis of the results, have come the conclusions and propositions what is necessary to conduct in the future researches.

KEYWORDS: combustion, diesel, biodiesel, waste, grape seeds

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ISTRAŽIVANJE PROCESA SAGREVANJA MEŠAVINE KONVENCIONALNOG DIZEL GORIVA I BIODIZELA GORIVA NAPRAVLJENOG OD OTPADNIH SEMENKI GROŽĐA

REZIME: Činjenica da se naftna kriza dešava širom sveta, alternative za konvencionalno dizel gorivo mogu se smatrati budućim rešenjem. Najbolja opcija za proizvodnju biodizela jeste njegova proizvodnja iz otpada. Na ovaj način, proizvodnja ne utiče na proizvodnju hrane, štaviše, potencijalni otpad se može iskoristiti za nešto korisno. U radu je sprovedena eksperimentalna analiza procesa sagorevanja mešavine napravljene od konvencionalnog dizel goriva i biodizel goriva napravljenog od otpadnih semenki grožđa. Proporcija ispitivane mešavine je 86 %vol dizel goriva i 14 %vol biodizel goriva. Svi rezultati su upoređeni sa procesom sagorevanja kada je dizel gorivo korišćeno kao jedino gorivo. Na osnovu rezultata, doneti su zaključci i predlozi šta je potrebno sprovesti u budućim istraživanjima.

KLJUČNE REČI: sagorevanje, dizel gorivo, biodizel gorivo, otpad, semenke grožđa

INTRODUCTION

Biodiesel represents one of the most established renewable alternatives to conventional diesel fuel (D100) in road transportation. Its application is motivated by the need to reduce dependence on fossil fuels and to improve the sustainability of the transport sector. Nevertheless, biodiesel differs from conventional diesel in several important physicochemical properties, including density, viscosity, oxygen content, volatility, and heating value. These differences directly influence fuel injection, ignition, combustion development, heat release, and, consequently, the energy and environmental performance of diesel engines (Ekbom, T. 2023; Nguyen, V. G. et al. 2023; Knežević, D. M. et al. 2020).

Most commercially available biodiesel is produced through alcohol-based transesterification and consists predominantly of fatty acid esters. The properties of the resulting fuel depend not only on the production process but also on the origin and chemical composition of the feedstock. Consequently, biodiesel obtained from different vegetable oils, animal fats, or waste materials may exhibit considerably different combustion characteristics and engine performance. For this reason, the selection of an appropriate feedstock is an important aspect of biodiesel development, particularly when the objective is to combine acceptable engine performance with improved resource utilization (Ekbom, T. 2023; Nguyen, V. G. et al. 2023; Hunich, J. et al. 2021).

In practical applications, biodiesel is generally used as a component of blends with conventional diesel rather than as a neat fuel. The use of biodiesel–diesel blends can facilitate the integration of renewable fuels into existing diesel-engine technology without requiring substantial engine modifications. However, increasing the biodiesel fraction may alter combustion characteristics and may result in changes in brake thermal efficiency (BTE), brake-specific fuel consumption (BSFC), cylinder pressure, and heat release behavior. Previous investigations have demonstrated that these effects depend strongly on the type of biodiesel and its concentration in the blend (Asokan, M. A. et al. 2021; Gautam, R., & Kumar, S. 2020; Behçet, R. et al. 2014).

Research has increasingly focused on biodiesel obtained from waste materials because such feedstocks can reduce production costs while simultaneously providing a useful route for valorizing residues generated by agricultural and food-processing activities. Waste animal fats, used cooking oils, fish-processing residues, and other biomass-derived materials have been investigated as potential biodiesel feedstocks, with their effects on combustion and engine performance differing according to their physicochemical characteristics (Gautam, R., & Kumar, S. 2020; Behçet, R. et al. 2014; Emma, A. F. et al. 2022). Biodiesel derived from waste materials is therefore of particular interest because its use may provide both energy-related and environmental benefits.

Among the potential waste-derived feedstocks, grape-processing residues represent an interesting resource for biodiesel production. The wine industry generates substantial quantities of solid residues, including grape seeds, which contain oil suitable for conversion into biodiesel. The utilization of grape seed oil can contribute to the valorization of an otherwise underutilized by-product while reducing the reliance on oils obtained from purpose-grown energy crops. Previous studies have investigated grape seed-derived biodiesel and its blends with conventional diesel, demonstrating that the resulting fuels can be used in compression-ignition engines and that their combustion and performance characteristics are generally comparable to those of conventional diesel, although differences in efficiency and fuel consumption may occur (Chelladorai, P. et al. 2018; Azad, A. K. & Rasul, M. G. 2019).

Despite the growing body of research on biodiesel from various renewable and waste feedstocks, further investigation is required to establish the influence of the biodiesel fraction on the combustion process and engine efficiency under different operating conditions. This is particularly relevant for biodiesel produced from waste grape seed oil, for which the relationship between blend composition, heat release characteristics, and brake thermal efficiency remains worthy of further examination.

Objective and Scope of the Research

The objective of this study is to evaluate the influence of the proportion of biodiesel produced from waste grape seed oil in blends with conventional diesel fuel on the combustion process and energy efficiency of a diesel engine. Particular attention is given to the heat release rate and brake thermal efficiency obtained under different engine operating conditions. The experimental investigation compares conventional diesel fuel (D100) with B7 and B14 blends, thereby enabling the effect of increasing the waste grape seed biodiesel content to be assessed within a practically relevant concentration range.

The results are intended to contribute to a better understanding of the combustion behavior of waste-derived biodiesel blends and to provide additional evidence regarding their suitability as alternative fuels for conventional compression-ignition engines.

EXPERIMENTAL PROCEDURE

The combustion process was investigated by measuring the instantaneous in-cylinder pressure over the engine cycle. The experimental setup consisted of a pressure measurement and crank-angle recording system, comprising a piezoelectric pressure transducer, signal-conditioning units, an optical crank-angle encoder with TDC detection, and a digital data-acquisition system. The measuring chain included an AVL QC32D pressure sensor (1), Kistler 5007 amplifier (2), angle encoder (3), optical transmitter (4), AVL 365CC signal multiplier (5), AVL Indimeter 619 acquisition system (6), and AVL IndiCom 1.2 (7) software, Figure 1.

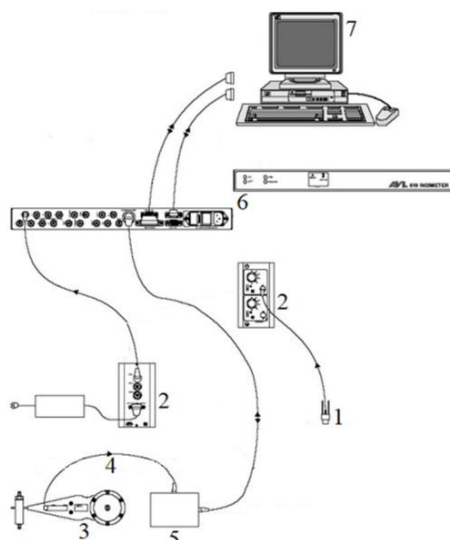


Figure 1 The measuring chain

Prior to the measurements, the pressure transducer was calibrated using a dead-weight calibration procedure. The resulting calibration coefficient was 9.97 bar/V. The engine operating points were selected based on its performance characteristics. To ensure that the selected speeds were defined according to a standardized procedure and could subsequently be compared with results from other studies, the reference speeds were determined in accordance with the European Stationary Cycle (ESC) methodology.

Since the tested engine is intended for applications in small agricultural machinery, particular attention was given to medium-high and full-load operation, which represent characteristic working conditions for this type of engine. Accordingly, the combustion analysis was performed at BMEP values of 1.4 bar, corresponding to low-load operation, respectively.

Three fuels were investigated: conventional diesel fuel (D100), and blend containing biodiesel produced from waste grape seed oil, namely B14. For each operating condition, pressure data were recorded over 50 consecutive engine cycles. Each measurement was repeated three times, and the obtained results were subsequently averaged.

During testing, the required engine speed and load were first established and maintained at the selected operating point. Measurement stability was assessed primarily from the variation in engine speed during data acquisition. The minimum, mean, and maximum engine speeds, together with their standard deviations, were determined for each operating condition to characterize the stability of the experimental regimes.

RESULTS AND DISCUSSION

The results obtained for the in-cylinder pressure and heat release rate are presented in Figures 2–4. These parameters were selected to provide an assessment of the combustion process for the investigated fuels under the considered engine operating conditions. The in-cylinder pressure traces provide an overall indication of the development of combustion and the associated pressure rise, while the heat release rate enables a more detailed assessment of the intensity and temporal distribution of the combustion process.

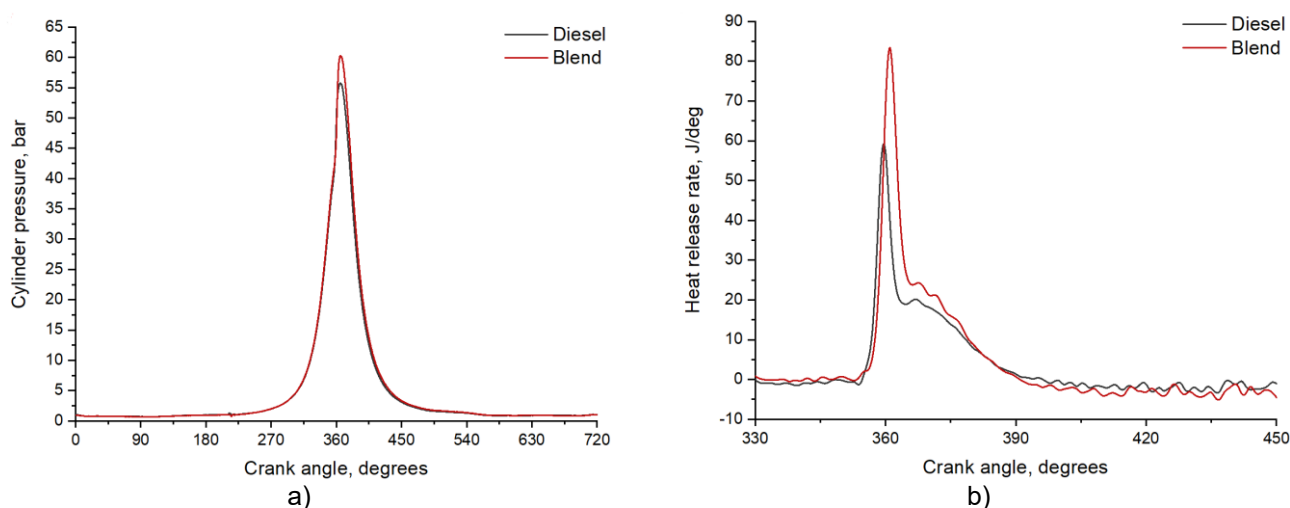


Figure 2 Cylinder pressure (a) and heat release rate (b) for engine speed 1635

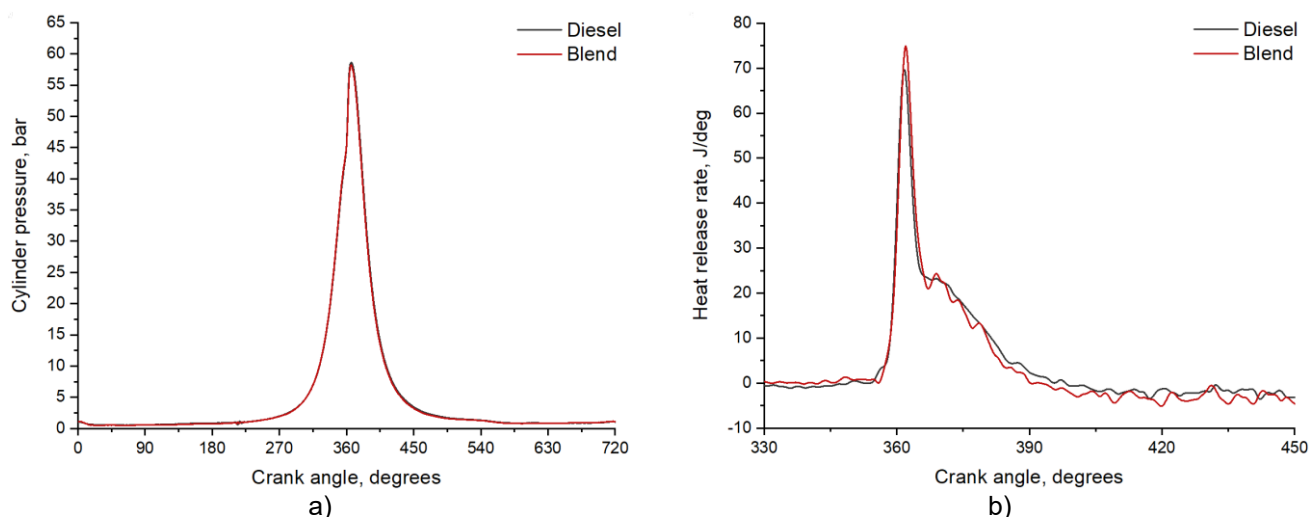


Figure 3 Cylinder pressure (a) and heat release rate (b) for engine speed 1937

A general tendency toward more intense combustion can be observed for the biodiesel–diesel blends compared with conventional diesel fuel. This behavior is reflected in both the in-cylinder pressure development and the heat release rate, with the differences being particularly evident during the period of uncontrolled combustion. The biodiesel blends generally exhibit a more pronounced heat release during this stage, indicating a faster energy release once the accumulated fuel becomes involved in the combustion process. Consequently, the pressure rise associated with this phase is also more pronounced than that observed for D100 under comparable operating conditions.

The observed behavior can primarily be associated with changes in the ignition delay period resulting from the physicochemical characteristics of the biodiesel-containing fuels. The use of biodiesel blends appears to extend the period between the start of fuel injection and the onset of significant combustion. Such an extension of the induction period allows a larger fraction of the injected fuel to accumulate in the combustion chamber before the onset of the uncontrolled combustion phase. Once ignition occurs, the accumulated fuel is rapidly consumed, resulting in a more

intense premixed combustion phase and, consequently, a higher rate of heat release. This mechanism provides a plausible explanation for the more pronounced combustion intensity observed for B7 and B14 compared with D100.

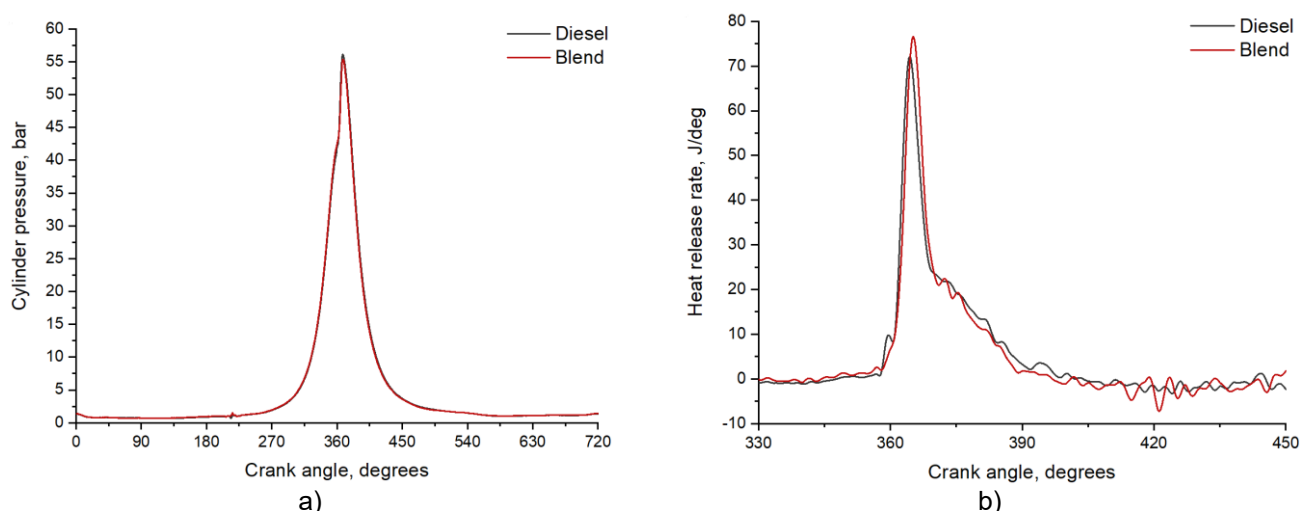


Figure 4 Cylinder pressure (a) and heat reease rate (b) for engine speed 2239

The increase in ignition delay observed for the biodiesel-containing blends may be related to their less favorable volatility characteristics compared with conventional diesel fuel. Reduced fuel volatility can affect the evaporation and preparation of the injected fuel for combustion, thereby influencing the time required to form an adequately combustible mixture. As a consequence, a greater amount of fuel may be present in a combustible state at the moment of ignition, promoting a more rapid release of the accumulated chemical energy during the subsequent uncontrolled combustion phase. The observed differences should therefore be interpreted primarily as a consequence of the altered fuel preparation and ignition characteristics associated with the use of biodiesel.

The effect is most pronounced at the lowest investigated engine speed. This behavior is consistent with the shorter available time for the individual combustion phases as engine speed increases. With increasing rotational speed, the duration of the combustion process expressed in crank-angle-related temporal terms changes, reducing the opportunity for differences in fuel preparation and ignition delay to develop to the same extent. Accordingly, the differences between the combustion characteristics of D100 and the biodiesel–diesel blends gradually become less pronounced as engine speed increases.

At higher engine speeds, the pressure development and heat release characteristics of the biodiesel blends consequently tend to approach those obtained with conventional diesel fuel. This indicates that the influence of the biodiesel component on the combustion process is strongly dependent on engine speed, with the effect of the altered fuel properties being most evident under low-speed operation. Overall, the results indicate that the addition of biodiesel produced from waste grape seed oil modifies the combustion process primarily through its influence on the ignition and premixed combustion phases, while the magnitude of this influence decreases with increasing engine speed.

CONCLUSIONS

This study investigated the influence of biodiesel produced from waste grape seed oil on the combustion process of a compression-ignition engine when used in blends with conventional diesel fuel. The analysis was based on in-cylinder pressure and heat release rate measurements obtained for D100, B7, and B14 fuels under medium-high and full-load operating conditions and at different engine speeds.

The results indicate that the addition of waste grape seed biodiesel modifies the combustion process compared with conventional diesel fuel. In general, both biodiesel–diesel blends exhibited a tendency toward more intense combustion, particularly during the uncontrolled combustion phase. This behavior was reflected in the more pronounced heat release and corresponding changes in the in-cylinder pressure development. The observed differences are primarily associated with changes in the ignition delay and fuel preparation characteristics of the biodiesel-containing blends.

The increased intensity of the uncontrolled combustion phase can be attributed to the accumulation of a larger quantity of fuel during the extended induction period preceding the onset of combustion. Once ignition occurs, this accumulated fuel undergoes relatively rapid combustion, resulting in a higher heat release rate compared with D100. The observed extension of the induction period is most likely related to the less favorable volatility characteristics of the biodiesel used in the investigated blends, which can influence fuel evaporation and mixture preparation.

The influence of biodiesel addition was found to be most pronounced at the lowest investigated engine speed. With increasing engine speed, the differences between the combustion characteristics of the biodiesel blends and D100 gradually decreased. At higher speeds, the pressure and heat release characteristics of B7 and B14 approached those of conventional diesel fuel, indicating a reduction in the relative influence of biodiesel on the combustion process.

Overall, the results demonstrate that waste grape seed oil biodiesel can be incorporated into conventional diesel fuel without fundamentally altering the combustion behavior of the engine. However, its presence affects the intensity and temporal development of combustion, with the magnitude of these effects depending on the biodiesel concentration and engine operating conditions. The findings support the potential use of waste grape seed biodiesel as a renewable fuel component while highlighting the importance of considering engine speed and blend composition when evaluating its combustion characteristics.

ACKNOWLEDGMENTS

This work presents the results of research conducted within projects financially supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, under Contract No. 451-03-34/2026-03/200107, dated 5 February 2026.

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