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PDV 30/31-03951-6

Kotor, 4.06. 2024.
Broj 01-1612

UNIVERZITET CRNE GORE
ODBOR ZA DOKTORSKE STUDIJE
SENAT UNIVERZITETA

Poštovani,

U prilogu dostavljam materijale u vezi predlaganja komisije za ocjenu doktorske disertacije „Optimizacija sastava izduvne emisije iz brodskih dizel motora upotrebom biodizela druge generacije" mr Nade Marstijepović Đurđić, na dalji postupak.

Srdačno,

UNIVERZITET CRNE GORE Pomorski fakultet Kotor

DEKANICA
Prof.dr Tatijana Dlabač

ISPUNJENOST USLOVA DOKTORANDA

OPŠTI PODACI O DOKTORANDU			
Titula, ime, ime roditelja, prezime	Mr Nada Marstijepović Đurđić		
Fakultet	Pomorski fakultet Kotor		
Studijski program	Pomorske nauke		
Broj indeksa	3/2011		
NAZIV DOKTORSKE DISERTACIJE			
Na službenom jeziku	Optimizacija sastava izduvne emisije iz brodskih dizel motora upotrebom biodizela druge generacije		
Na engleskom jeziku	Optimising the composition of exhaust emissions from marine diesel engines using second generation biodiesel		
Naučna oblast	Pomorske nauke		
MENTOR/MENTORI			
Prvi mentor	Prof. dr Danilo Nikolić	Pomorski fakultet Kotor	Motori i vozila
Drugi mentor	-	-	-
KOMISIJA ZA PREGLED I OCJENU DOKTORSKE DISERTACIJE			
Prof. dr Nikola Račić		Pomorski fakultet Sveučilišta u Splitu, Hrvatska	Brodsko inžinjerstvo
Prof.dr Danilo Nikolić		Pomorski fakultet Kotor Univerziteta Crne Gore, Crna Gora	Motori i vozila
Doc.dr Miroslav Vukičević		Pomorski fakultet Kotor Univerziteta Crne Gore, Crna Gora	Brodomašinstvo

Datum značajni za ocjenu doktorske disertacije	
Sjednica Senata na kojoj je data saglasnost na ocjenu teme i kandidata	23.05. 2013. godine
Dostavljanja doktorske disertacije organizacionoj jedinici i saglasanost mentora	15.05. 2024. godine
Sjednica Vijeća organizacione jedinice na kojoj je dat prijedlog za imenovanje komisija za pregled i ocjenu doktorske disertacije	31.05. 2024. godine

ISPUNJENOST USLOVA DOKTORANDA

U skladu sa članom 38 pravila doktorskih studija kandidat **je/nije** cjelokupna ili dio sopstvenih istraživanja vezanih za doktorsku disertaciju publikovao u časopisu sa **(SCI/SCIE)/(SSCI/A&HCI)** liste kao prvi autor.

Spisak radova doktoranda iz oblasti doktorskih studija koje je publikovao u časopisima sa (upisati odgovarajuću listu)

1. **Marstijepovic, N.,** Cvrk, S., Gagic, R., Filipovic, I. Nikolic, D. (**2023**). APPLICATION OF BIODIESEL DERIVED FROM OLIVE OIL PRODUCTION WASTES AT MARINE DIESEL ENGINE AND EVALUATION OF GASSEOUS EMISSION TRENDS. **Thermal Science** (izdavač: Institut za nuklearne nauke Vinča, Srbija), Volume 27, Issue 3 Part B, Pages: 2195-2203, https://doi.org/10.2298/TSCI220707218M. https://mjl.clarivate.com:/search-results?issn=0354-9836&hide_exact_match_fl=true&utm_source=mjl&utm_medium=share-by-link&utm_campaign=search-results-share-this-journal
2. Nikolic, D., Cvrk, S., **Marstijepovic, N.,** Gagic, R., Filipovic, I. (**2017**). INFLUENCE OF BIODIESEL BLENDS ON CHARACTERISTICS OF GASEOUS EMISSIONS FROM TWO STROKE, LOW SPEED MARINE DIESEL ENGINES. In: Pellicer, E., et al. Advances in Applications of Industrial Biomaterials. **Springer**, Cham. https://doi.org/10.1007/978-3-319-62767-0_3
3. Nikolić, D., **Marstijepović, N.,** Cvrk, S., Gagić, R. i Filipović, I. (**2016**). EVALUATION OF POLLUTANT EMISSIONS FROM TWO-STROKE MARINE DIESEL ENGINE FUELED WITH BIODIESEL PRODUCED FROM VARIOUS WASTE OILS AND DIESEL BLENDS. **Brodogradnja**, 67 (4), 81-90. https://doi.org/10.21278/brod67406

Obrazloženje mentora o korišćenju doktorske disertacije u publikovanim radovima

U disertaciji je istražena mogućnost primjene biodizela druge generacije proizvedenog od sirovina koje su na raspolaganju u Crnoj Gori, otpadnog palminog i suncokretovog ulja iz restorana, kao i otpadnog sirovog ulja komine masline žutice prikupljenog od proizvođača maslinovog ulja iz okoline Bara, za pogon brodskih dizel motora. Sirovine su podvrgnute postupku transesterifikacije u laboratorijskim uslovima kako bi se proizvele tri vrste biodizela, nakon čega su se umiješale sa čistim dizel-gorivom u tri različite zapremine: 7 %, 20 % i 25 % v/v, te na taj način za potrebe istraživanja proizvelo 10 vrsta različitih goriva/smjesa. Za potrebe ispitivanja goriva korišćen je dvotaktni sporohodni brodski dizel-motor, koji nije posjedovao tehnologije za smanjenje emisije gasovitih zagađivača, što ga je činilo pogodnim za ovu vrstu istraživanja. Smjese goriva su ispitane sa stanovišta energetskih parametara i emisije gasovitih zagađivača iz brodskog dizel motora.

Doktorantkinja Mr Nada Marstijepović Đurđić je objavila tri naučno-istraživačka rada u renomiranim časopisima (SCIE lista i renomirani Izdavač) iz sprovedenog istraživanja u okviru doktorske disertacije. Na prva dva objavljena naučno-istraživačka rada je bila prvi, odnosno drugi ko-autor, što je u vrijeme predaje naučnih radova na recenziranje bio dovoljan uslov da disertacija može da ide na postupak ocjenjivanja. Kako je između predaje radova na recenziranje i njihovog zvaničnog objavljivanja došlo do izmjene pravila na doktorskim studijama, od doktorantkinje se nakon toga tražilo da objavi naučno-istraživači rad kao prvi autor, što je i uradila.

U naučno-istraživačkom radu objavljenom kao prvi autor (rad pod rednim brojem 1), doktorantkinja se osvrnula na laboratorijski proizveden biodizel od komine masline i njegovu primjenu u smjesi sa dizel gorivom. Dokazano je da se u laboratorijskim uslovima postupkom transesterifikacije može proizvesti određena količina biodizela iz otpadnih sirovina prilikom proizvodnje maslinovog ulja, u ovom slučaju barske žutice. Biodizel proizveden na ovaj način se umiješao u tri različita odnosa sa dizel gorivom, nakon čega se ispitala njegova primjena kao pogonskog goriva u brodskom dvotaktnom sporohodnom dizel motoru sa stanovišta energetskih parametara i emisije gasovitih zagađivača NOx, SO_2 i CO. Ispitivanjima je dokazano da se upotrebom biodizela u smjesama sa dizel gorivom do 25 %v/v može uspješno smanjiti emisija ovih gasovitih zagađivača.

U druga dva rada, doktorantkinja je ispitivala mogućnosti primjene biodizela proizvedenog od otpadnog jestivog palminog i suncokretovog ulja u brodskim dizel motorima. Sirovine su prethodno prikupljene u restoranima na crnogorskom primorju, nakon čegu su podvrgnute procesu transesterifikacije kako bi se proizveo biodizel. Sprovedeno ispitivanje na brodskom motoru sa razultatima i zaključcima su prezentirani u ova dva rada.

S obzirom da je doktorantkinja ispunila sve uslove propisane Statutom Univerziteta Crne Gore i Pravilima dokorskih studija, mentor je saglasan da se imenuje Komisija za pregled i ocjenu doktorske disertacije.

Datum i ovjera (pečat i potpis odgovorne osobe)		
U Kotoru, 31.5.2024.g.	UNIVERZITET CRNE GORE Pomorski fakultet Kotor MP	DEKAN

Prilog dokumenta sadrži:

1. Potvrdu o predaji doktorske disertacije organizacionoj jedinici
2. Odluku o imenovanju komisije za pregled i ocjenu doktorske disertacije
3. Kopiju rada publikovanog u časopisu sa odgovarajuće liste
4. Biografiju i bibliografiju kandidata
5. Biografiju i bibliografiju članova komisije za pregled i ocjenu doktorske disertacije sa potvrdom o izboru u odgovarajuće akademsko zvanje i potvrdom da barem jedan član komisije nije u radnom odnosu na Univerzitetu Crne Gore

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PDV 30/31-03951-6

Kotor, 15.05. 2024.
Broj 01-1480/2

Pomorski fakultet Kotor Univerziteta Crne Gore, izdaje sljedeću

POTVRDU

Potvrđuje se da je doktorand mr Nada Marstijepović Đurđić dana 15.05. 2024. godine predala na ocjenu svoju doktorsku disertaciju pod nazivom »Optimizacija sastava izduvne emisije iz brodskih dizel motora upotrebom biodizela druge generacije«.

SEKRETAR
Vera Popović

UNIVERZITET CRNE GORE
Pomorski fakultet Kotor

Na osnovu čl. 64. Statuta Univerziteta Crne Gore i čl. 38, 41. stav1 Pravila doktorskih studija, Vijeće Pomorskog fakulteta Kotor na sjednici odražanoj dana 31. 05. 2024. godine, donijelo je

ODLUKU

1. Utvrđuje se da su ispunjeni uslovi iz Pravila doktorskih studija za dalji rad na doktorskoj disretaciji „Optimizacija sastava izduvne emisije iz brodskih dizel motora upotrebom biodizela druge generacije", doktoranda mr Nade Marstijepović Đurđić.
2. Predlaže se Odboru za doktorske studije i Senatu Univerziteta Crne Gore da formira komisiju za ocjenu doktorske disertacije „Optimizacija sastava izduvne emisije iz brodskih dizel motora upotrebom biodizela druge generacije", doktoranda mr Nade Marstijepović Đurđić u sastavu:

- **Dr Nikola Račić, redovni profesor Pomorskog fakulteta Sveučilišta u Splitu, oblast Brodsko inžinjerstvo, predsjednik.**
- **Dr Danilo Nikolić, redovni profesor Pomorskog fakulteta Kotor Univerziteta Crne Gore, oblast Motori i vozila, mentor,**
- **Doc.dr Miroslav Vukičević, Pomorski fakultet Kotor Univerziteta Crne Gore, oblast Brodomašinstvo, član.**

3. Odluka se sa pratećim materijalima dostavlja Odboru za doktorske studije i Senatu Univerziteta Crne Gore.

O b r a z l o ž e nj e

Doktorand mr Nada Marstijepović Đurđić je uradila svoju doktorsku disertaciju „Optimizacija sastava izduvne emisije iz brodskih dizel motora upotrebom biodizela druge generacije", istu predala i uputila molbu Komisiji za doktorske studije i Vijeću Pomorskog fakulteta Kotor da predlože sastav Komisije za ocjenu disertacije.

Na osnovu podnijete dokumetacije i saglasnosti Komisije za doktorske studije, Vijeće je donijelo odluku kao u dispozitivu.

Odluka se sa pratećim materijalima dostavlja Odboru za doktorske studije i Senatu Univerziteta Crne Gore.

VIJEĆE POMORSKOG FAKULTETA KOTOR

Broj 01- 1591
Kotor, 31.05. 2024.

DEKANICA
Prof.dr Tatijana Dlabač

UNIVERZITET CRNE GORE
Pomorski fakultet Kotor

POMORSKI FAKULTET KOTOR
KOMISIJI ZA DOKTORSKE STUDIJE
VIJEĆU FAKULTETA

PREDMET: Predaja doktorske disertacije

Poštovani,

Predajem svoju doktorsku disertaciju pod nazivom „Optimizacija sastava izduvne emisije iz brodskih dizel motora upotrebom biodizela druge generacije", u dovoljnom broju primjeraka, u pisanoj i elektronskoj formi sa pratećim izjavama. Takođe predajem i pisanu saglasnost mentora, biografiju i kopije naučnih radova. Molim da predložite sastav komisije za ocjenu moje doktorske disertacije i sprovedete dalji postupak.

Srdačno,

DOKTORAND
Mr Nada Marstijepović Đurđić

VIJEĆU POMORSKOG FAKULTETA KOTOR

KOMISIJI ZA DOKTORSKE STUDIJE POMORSKOG FAKULTETA KOTOR

Na osnovu člana 37. Pravila doktorskih studija Univerziteta Crne Gore dajem sljedeću:

SAGLASNOST

da rad pod nazivom: **"Optimizacija sastava izduvne emisije iz brodskih dizel motora upotrebom biodizela druge generacije"** autorke mr Nade Marstijepović Đurđić, zadovoljava kriterijume doktorske disertacije propisane Statutom Univerziteta Crne Gore i Pravilima doktorskih studija.

U Kotoru, 29. 04. 2024. godine

Mentor

Prof. dr Danilo Nikolić

Biografija autora

Nada Marstijepović Đurđić rođena je u Baru, đje je završila osnovnu i srednju školu. Fakultet za Fizičku hemiju završila je u Beogradu kao i diplomske akademske studije fizičke hemije (diplomirani fizikohemičar-master). Magistarske akademske studije program Hemijske tehnologije smjer Neorganske hemije završila je na Metelurško-Tehnološkorn fakultetu u Podgoricu i stekla zvanje Magistra nauka. Završila je Diplomatsku Akademiju «Gavro Vuković« u Podgoricu. Radila je u Ekotoksikološkorn institutu u Podgoricu, u Upravi policije Crne Gore u Centru za krirninalističku tehniku. Radi u Ministarstvu unutrasnjih poslova Crna Gore. Sudski je vještak iz oblasti fiziko-hemijske-ekološke struke i zaštite životne sredine od 23.09.2010.godine. Učesnik je na više domaćih i međunarodnih konferencija, kongresa i simpozijuma iz oblasti fizike, hemije i životne sredine, ekologije, fundementelne fizičke hemije, bezbjednosti, rizika i dr. Predsjednik je i organizator Prve i Druge Međunarodne Konferencije ZEB-PES 2012 Bar i ZEB-PES 2013 Bar (zaštita, ekologija, bezbjednost-protect, ecology, safety) Crna Gora. Član je Inženjerske komore Crne Gore. Član je Matice Crnogorske. Član je Udruženja sudskih vještaka Crne Gore. Posjeduje Licencu za izradu projekata i elaborata procjene uticaja na životnu sredinu. Znanje engleskog jezika i rada na računaru. Služi se albanskim jezikom. Profesionalno je igrala košarku. Crnogorske je nacionalnosti. Udata je i majka dva đeteta Dara i Eva.

Bibliografija naučnih aktivnosti

Časopisi:

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[2] Nada Marstijepović. „Rizici koji nastaju pri hemijskim udesima na postrojenjima pri transportu opasnih materija" (Perjanik, br.17/18, str.123-129, Podgorica, 2008., Crna Gora, UDC 377.5:351.74(497.16)(082), ISSN 1451-3412 , UDK 504.5:656.073.436).

[3] Nada Marstijepović. „Sprečavanje širenja šumskih požara upotrebom eksploziva" (Perjanik, br.19/20, str.89-94, Podgorica, 2009., Crna Gora, UDC 377.5:351.74(497.16)(082), ISSN 1451-3412 , UDK 614.842.6:622.235).

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[5] Nada Marstijepović. „Eksplozivne materije" (Perjanik, br.22/23, str.117-125, Podgorica, 2009., Crna Gora, UDC 377.5:351.74(497.16)(082), ISSN 1451-3412 , UDK 662.1/4).

[6] Nada Marstijepović. „Toksični i biološki agensi " (Perjanik, br.24, str.86-97, Podgorica, 2010., Crna Gora, UDC 377.5:351.74(497.16)(082), ISSN 1451-3412 , UDK 623.458/.459).

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[11] Nikolić D., Cvrk S., Marstijepović Nada, Gagic R., Filipovic I., Influence of Biodiesel Blends Chracteristics of Gaseous Emissions From Two Stroke, Low Speed Marine Diesel

Engines. Advances in Application of Industrial Biomaterials pp 49 - 63. Print ISBN 978-3-319-62766- 3, online ISBN 978-3-319-62767-0. Izdavač: Springer. 2017 (https://doi.org/10.1007/978-3- 319-62767-0_3).

[12]. Marstijepović Nada, Cvrk S., Gagic R., Filipovic I., Nikolić D., Application of Biodiesel Derived From Olive Oil Production Wastes at Marine Diesel Engine and Evaluation of Gasseous Emission Trends, Thermal Science, 2022, https://doi.org/10.2298/TSCI220707218M (https://thermalscience.vinca.rs/onlinefirst/5094).

Domaće konferencije:

[1] N. Marstijepović, S. Đurković, M.M. Krgović, M. Ivanović, R. Zejak, M.Knežević. „ The influence of the presence of quartz in illite-kaolinit clays on the properties of sintered product" (1st Simposium of chemistry and Environment, Miločer-Budva, abstrakt str.176.,2007., Crna Gora),

[2] Nada Marstijepović, Dragica Kovačević, Zorica Potpara. „Sdržaj i način obrazovanja u zaštiti životne sredine" (Prva Međunarodna Konferencija ZEB-PES 2012,str.143-150 Bar, 2012.,Crna Gora, ISBN: 978-86-80031-46-0).

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[4] Aleksandar Kovačević, Nada Marstijepović. „Pravna zaštita životne sredine" (Prva Međunarodna Konferencija ZEB-PES 2012,str.151-159 Bar, 2012.,Crna Gora, ISBN: 978-86-80031-46-0).

[5] Nada Marstijepović, Danilo Sekulović, Aleksandar Ivanović, Danilo Nikolić, „Trenutno stanje na tržištu biogoriva" (Drugi Međunarodni simpozijum o koroziji i zaštiti materijala i životnoj sredini,CDZM, str.253-259 Bar 2012., Crna Gora, ISBN: 978-9940-9334-1-8).

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[9] N. Marstijepović, Sead Cvrk, Danilo Nikolić, „Smanjenje štetnih uticaja upotrebom biogoriva-biodizela u transportnom sektoru u Crnoj Gori" (Crnogorsko društvo za koroziju, zaštitu materijala i zaštitu životne sredine „DRUGI MEĐUNARODNI SIMPOZIJUM O KOROZIJI I ZAŠTITI MATERIJALA I ŽIVOTNOJ SREDINI" oktobar 2016., str.323-336 Bar, Crna Gora, ISBN: 978-9940-9334-2-5, COBISS.CG-ID 31527696).

Međunarodne konferencije:

[1] M. Krgović, S. Đurković, N. Marstijepović, M. Ivanović, R. Zejak, M. Knežević. „ The possibilities of using elecrto filter ash of steam power plant „Pljevlja" as raw materials mixture component for obtaining sintered product" (Ninth Annular Conference YUKOMAT, str.94 Herceg Novi, 2007., P.S.A.52 The book of Abstracts, 2007.,Srbija).

[2] N. Marstijepović, M. Ivanović, M.M. Krgović, I. Bošković, M.Knežević, R. Zejak. „Microstructure of a sintered producr on the basis of illite- kaolinite clays" - (Tenth Annular Conference YUKOMAT, Herceg Novi, 2008., The book of Abstracts, 2008., Srbija).

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Influence of Biodiesel Blends on Characteristics of Gaseous Emissions from Two Stroke, Low Speed Marine Diesel Engines

Danilo Nikolic, Sead Cvrk, Nada Marstijepovic, Radmila Gagic and Ivan Filipovic

Abstract As a renewable source of energy, biofuels have a favourable impact on the environment and can replace fossil fuels to some extent. Biodiesel is one option for reducing the emission of pollutants and GHG in the shipping sector. By 2030, Lloyd Register predicts a global demand for about 100 million tons of biofuel in shipping, mostly biodiesel. This study investigates the influence of biodiesel blends on the characteristics of gaseous emissions from a two-stroke, low speed marine diesel engine. For this research, a reversible low-speed two-stroke marine diesel engine was used, without any after-treatment devices installed or engine control technology for reducing pollutant emission. Tests were carried out on three regimes of engine speed, 150, 180 and 210 rpm under heavy propeller condition, while the ship was berthed in the harbour. The engine was fuelled with low sulfur diesel fuel and blends containing 7 and 25% v/v of three types of second-generation biodiesel made from cast-off sunflower and palm oil waste from frying. For biodiesel production, a base-catalyzed transesterification was implemented. Biodiesel blends show better emission performance in regard to NOx, SO_2, CO, and CO_2 than pure low sulfur diesel fuel.

Keywords Used frying oils · Biodiesel · Low sulfur diesel fuel · Two-stroke low speed marine diesel engine · Gaseous emission

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E. Pellicer et al. (eds.), *Advances in Applications of Industrial Biomaterials*,
DOI 10.1007/978-3-319-62767-0_3

1 Introduction

The continuous increase in international maritime traffic has correspondingly increased marine fuel consumption from about 250 million to 325 million tons over the period from 2007 to 2012 (IMO 2014). As a consequence, ships were responsible for 13, 15 and 2.2 (on an average annual basis) of global sulfur oxide (SOx), nitrogen oxide (NOx) and carbon dioxide (CO_2) emissions, respectively (IMO 2014). A ship's exhaust emission can be transported hundreds of kilometres inland. The median transport velocity of SOx and NOx is around 400 kilometres per day, while mean residence time is 1–3 days, indicating mean transport distances of 400–1200 km (Lamas and Rodriguez 2012).

The International Maritime Organization (IMO) recognizes the importance and need to limit the emission of pollutants and greenhouse gases originating from marine diesel engines. An International Convention for the Prevention of Pollution from Ships—MARPOL 73/78—was adopted by the IMO's Marine Environment Protection Committee (MEPC). The MARPOL Convention was amended in September 1997 to add the Protocol, which includes Annex VI, "Regulations for the Prevention of Air Pollution from Ships." Annex VI sets limits on SOx and NOx emissions, prohibits deliberate emissions of ozone-depleting substances, and also regulates emissions of VOC from tankers along with shipboard incineration. This Protocol entered into force on May 19th, 2005, and applies to all engines with over 130 kW of power. The MEPC revised MARPOL Annex VI with the aim of further strengthening emission limits and requirements pertaining to the sulfur levels in marine fuels. The amendments entered into force on July 1st, 2010. A new chapter "Review of Synthetic Fuels and New Materials Production Based on Pyrolysis Technologies" of Annex VI, entitled "Regulations on energy efficiency for ships," is aimed towards reduction of greenhouse gas (GHG) emissions from ships. Chapter "Review of Synthetic Fuels and New Materials Production Based on Pyrolysis Technologies" includes a set of technical and operational measures, in order to improve the energy efficiency of ships. This chapter entered into force in January 2013 and applies to all ships of over 400 gross tonnage. The IMO believes that these measures could help in reducing CO_2 emissions by between 45 to 50 million tons on an annual basis by 2020 (IMO 2015).

Biofuels could be an option for low carbon intensity in shipping. They are renewable and can be produced locally. The main drawbacks of biofuels are the limitation of raw materials and production costs. In general, the first generation of biofuels has been produced from grains, oil crops and sugar crops. These resources for the production of biofuels are limited. There is a threshold beyond which the production of sufficient biofuel would jeopardize food supplies and biodiversity. Since the first generation of biofuels has certain limitations, the second and third generations of biofuels are already under development worldwide. The basic raw material for production of the second generation of biofuels is biomass, which consists of the remains of the inedible portions of crops, other crops that are not used for food purposes, and industrial waste such as wood chips, bark and pulp from the processing of fruit and many other items. The third generation of biofuels includes production from microalgae. The price of biofuels is another key factor limiting their widespread use, mainly because of their higher cost of production compared to fossil fuels.

There is little practical experience with the use of biofuels in shipping. Several companies have tested biofuels, mostly in cargo and passenger ship engines. Most of these experiments have been carried out by shipping companies, sometimes in cooperation with classification societies. Tests were mostly conducted using FAME (fatty acid methyl esters—biodiesel), vegetable oils and BioLNG (Florentinus et al. 2011). The implementation of biodiesel as a marine fuel was tested in several research programs (RCCL Project Royal Caribbean—Cruises testing on biodiesel, MAERSK/LR Project, BV energy Project, Earthrace), in which certain advantages of biodiesel over fossil fuels were noted: blending can be made up to 100% of biodiesel, there was a reduction in particulate emissions, no adverse effects were detected in marine engines, and no bacterial formations were detected in tanks of biofuels during storage for more than 6 months. The potential problems when using biodiesel are: it acts as a solvent and tends to soften and degrade certain rubber and elastomer compounds that are often used in older engines, and it can easily remove deposits that remain after diesel fuel has been in the system, and thus clog filters (Florentinus et al. 2011). The IMO study (IMO 2007) concluded that low blends of biodiesel up to 20% (B20) could be used without any fuel system degradation. The application of smaller biodiesel blends at marine fuels distillates could be introduced relatively easily. This compound could be prepared at the time of bunkering. These studies were conducted on medium speed 4-stroke marine diesel engines.

The used frying oils, generated from fried food, could be a candidate for biodiesel production in regions with negligible vegetable oil production. Wastes containing oils are products of decomposition that impair the oil's quality, causing a reduction in productivity in the trans-esterification reaction and also possibly generating undesirable by-products that can spoil the final product. Therefore, it is of great importance to refine used frying oils for biodiesel production, using filtration, de-acidification or neutralization and whitening processes.

The influence of biodiesel (FAME) blends with low sulfur diesel fuel on the characteristics of gaseous emissions from marine diesel engine was investigated. A reversible, two-stroke, low speed, cross-flow scavenging, 4-cylinder marine diesel engine was used for the experiment. The engine was fuelled with low sulfur diesel fuel and blends containing 7 and 25% of two types of biodiesel. The two types of biodiesel were produced under lab conditions, using cast-off sunflower and palm oil waste from frying. Base-catalysed trans-esterification was used in this research.

2 Experimental Procedure

For this study, a marine diesel engine was employed. It was a reversible 4—cylinder, 2-stroke engine with cross-flow scavenging, model "ALPHA 494 R" produced by LITOSTROJ Ljubljana (Slovenia) under a Burmeister licence,

Table 1 Marine diesel engine specifications

Engine producer	Engine model	Working principle	Max power	Cyl. No.	Stroke/bore
Burmeister	Alpha 494-R	2-stroke	390 kW @ 320 rpm	4	490 mm/290 mm

Table 1. The engine can be regarded as low speed because the maximum engine speed is 320 min^{-1}, making a maximum power of 390 kW. Since it is an old type of marine diesel engine, there are no aftertreatment devices installed, nor any engine control technology for reducing pollutant emission. This is the preferable situation for an investigation of the direct influence of biodiesel on exhaust emissions from marine diesel engines.

The direct propulsion system of the ship is comprised of the engine, the propeller shaft that is connected to the output coupling, and the fixed pitch propeller. Measurements were made when the ship was berthed in the harbour. Running the engine when the ship is berthed is called a heavy propeller condition. For this reason, the measurements were carried out only on three regimes of engine speeds, 150, 180 and 210 min^{-1}.

During operation of the engine, power is constantly changing depending on the connected consumer. Under the conditions of operation of the vessel, the engine power that is transmitted to the fixed pitch propeller depends on the number of revolutions, pitch and propeller diameter. The resistance provided by the fixed pitch propeller is proportional to the square of the propeller speed:

$$M = k \cdot n^2 \tag{1}$$

Effective power, delivered to the propeller, can be expressed through the torque that is transmitted from the engine crankshaft via coupling to the propeller shaft and propeller, where it reverses the angular velocity ω. The recorded average torque and shaft speed data are used for effective engine power estimation in accordance with the formula (Borkowski et al. 2011)

$$P_e = M \cdot \omega = M \frac{\pi \cdot n}{30} [kW], \tag{2}$$

where:

M means the measured torque [kNm],
and n means the engine-propeller rotational speed [rpm].

For the set of different engine speeds of 150, 180 and 210 min^{-1} and the fuels, measurements of propeller shaft torque and power were conducted by means of strain gauges. This method established a functional connection between the elastic angular deformation of the propeller shaft and engine torque/power. Experimental measurements of propeller shaft torque and power are set as two pairs of type

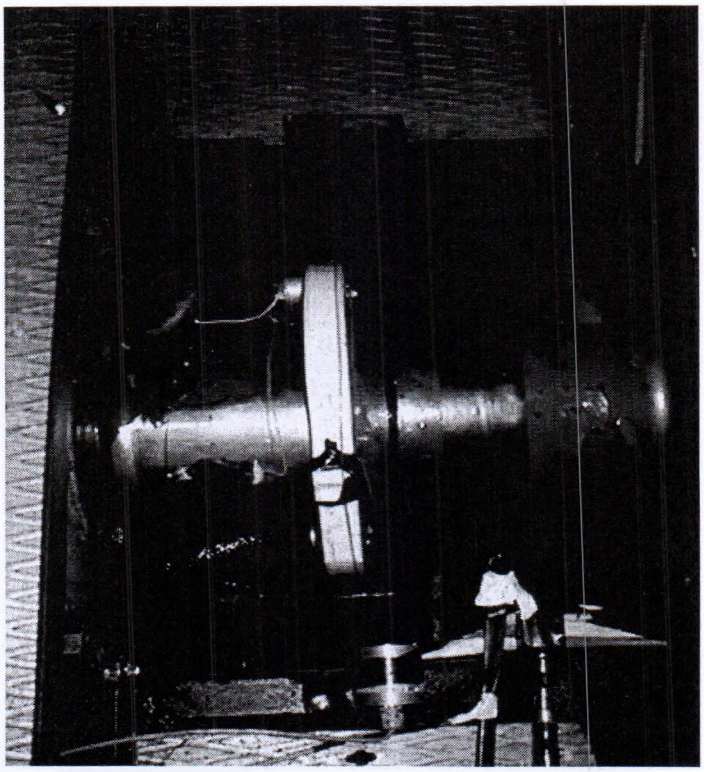

Fig. 1 Strain gauges mounted on the propeller shaft

XY21-6/350 strain gauges, connected in the Wheatstone bridge and powered with an AC voltage of 9 V, are installed onto the propeller shaft. The strain gauges are mounted at an angle of 180° relative to one another. From the Wheatstone bridge, a measuring signal is delivered to the radio transmitter, allowing a transfer of data to the receiver. A power source, transmitter and antenna are mounted on a ringed disc made of plastic in order to eliminate noise, and this is placed on the propeller shaft. Next to the shaft, a signal receiver and speed sensor are placed (Fig. 1). The signal receiver and speed sensor are connected to an electronic measuring device, the "Spider 8." The "Spider 8" is connected to a personal computer with "Catman 3.0" data processing software. Equipment was produced by Hottinger Baldwin MESSTEHNIK (HBM).

Hourly fuel consumption was measured for each engine speed and fuel type. For the fuel mass flow estimation, the volumetric method of fuel consumption measurement was employed according to the formula (Borkowski et al. 2011)

$$B = \frac{V_p \cdot \rho_p}{t}\,[\mathrm{kg/h}], \qquad (3)$$

where

B is the fuel mass flow [kg/h]
V_p is the fuel volume consumed during the measurement time [m^3]
ρ_p is the fuel gravity [kg/m^3]
and t is the time of measurement [h].

Table 2 Specification of exhaust emission analyser Testo, model 350-MARITIME

Parameter	Measuring range	Accuracy
°C, flue gas	−40 up to 1000 °C	max ±5 K
O_2	0 … 25 vol.%	
CO	0 … 3000 ppm	
NO	0 … 3000 ppm	
NO_2	0 … 500 ppm	
SO_2	0 … 3000 ppm	
CO_2	0 … 40 vol.%	
Pabs	600 … 1150 hPa	±5 hPa at 22 °C ±10 hPa at −5 °C up to 45 °C

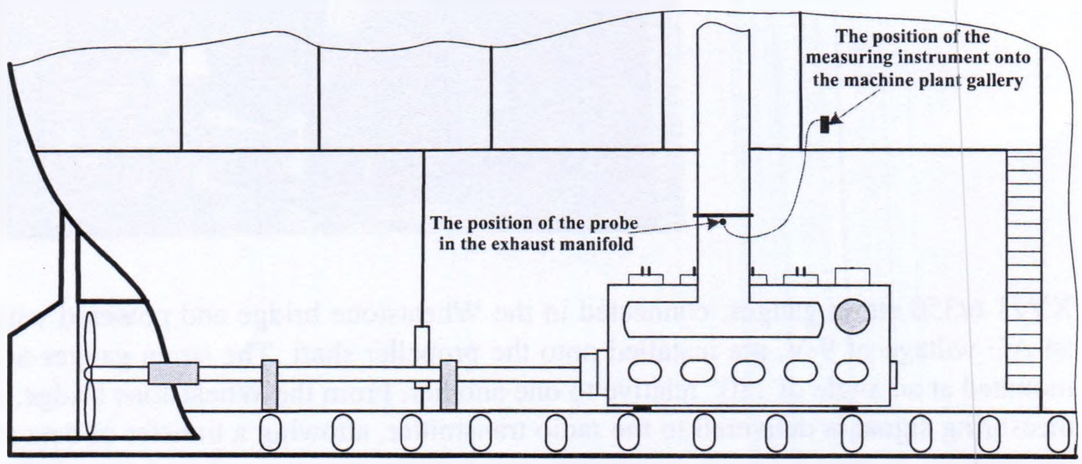

Fig. 2 Position of exhaust emission testing equipment

Exhaust emission analyser Testo, model 350-MARITIME, was used in the experiment for measuring SO_2, CO, NOx and CO_2 concentrations in the engine exhaust. Testo model 350-MARITIME has type approval by Germanisher Lloyd. The specification of the emission analyser is given in Table 2. The analyser was set on the gallery about two meters above the engine. The probe was positioned inside an opening of the exhaust gas collector. A lower part of the exhaust gas collector from the engine exhaust to the point of probe insertion was not cooled. Between each regime of engine speed, exhaust gas tests were conducted after the parameters of the engine, such as coolant and oil temperature, were stabilized. Figure 2 shows the schematic of the emission tests.

The marine diesel engine was fuelled with pure diesel fuel and blends containing 7 and 25% of two types of biodiesel (FAME), so there was no need for engine modifications. The diesel fuel was a representative fuel used by the fleet of Montenegrin vessel boats in territorial waters with a flashpoint above 60 °C. Biodiesel was produced under lab conditions, using cast-off sunflower and palm oil

Table 3 Test fuels basic properties

Parameters	Units	Fuel 1 DF	Fuel 2 DP7%	Fuel 3 DP25%	Fuel 4 DS7%	Fuel 5 DS25%
Density @ 15 °C	kg/m^3	833.4	836.37	844.8	837.2	846.6
Viscosity @ 40 °C	mm^2/s	2.92	3.00	3.21	2.95	3.23
Cetane number		51.3	52.5	53.9	53.5	54.2
Distillation % (v/v) recovered @ 250 °C % (v/v) recovered @ 350 °C 95% (v/v)	% (v/v) % (v/v) °C	29 91 354	26 92 356	20 92 360	28 91 357	19 89 361
Sulfur content	mg/kg	8.57	7.91	5.68	7.79	5.64
Water content	mg/kg	40.94	71.93	153.65	79.99	177.42
Total aromatics	% m/m	22.8	22.5	20.5	22.3	19.8
FAME content	v/v	0	7	25	7	25

waste from frying. This frying oil waste was collected from hotel restaurants. Base-catalysed trans-esterification was used for biodiesel production. The basic properties of the test fuel are given in Table 3, where DF stands for pure diesel fuel, DS stands for blends of diesel fuel and biodiesel made of sunflower oil waste from frying, and DP stands for blends of diesel fuel and biodiesel made of palm oil waste from frying. For blended fuels, to the initial letters, a percentage of biodiesel is added to it. The poor low-temperature properties of biodiesel were avoided by performing tests during the summer period. Also, the biodiesel was used in an experiment a couple days after it was produced in the laboratory, so the poor stability properties of biodiesel were avoided.

Tests were conducted under identical conditions. Fuel was supplied to the engine by an outside tank. For each fuel change, the fuel lines were purged, and the engine was left to run for a minimum 20 min in order to be stabilized under new conditions. Fuel samples were poured into separate tanks connected to the suction side of the engine fuel pump. Excess fuel was returned into the same tank. The tank was located on the gallery in the engine room about two meters above the engine, so that the fuel came to the fuel pump by force of gravity. A glass burette of known volume was used for fuel consumption measurements. It was attached in parallel to the tank.

The engine ran for 8600 h after the last overhaul, and there were no adjustments of the engine for this experiment. The purpose of the performed measurements was to determine trends of gaseous emissions in relation to different types and content of the second-generation biodiesel in the blends for the marine diesel engine in service.

Table 4 Dependence of engine speed on torque, effective power and fuel consumption

Engine speed, rpm	Torque, Nm	Effective power (propeller), kW	Fuel consumption, kg/h				
			Fuel 1 DF	Fuel 2 DP7%	Fuel 3 DP25%	Fuel 4 DS7%	Fuel 5 DS25%
150	4267	67	15.30	15.30	15.90	16.00	16.35
180	5609	105	23.20	23.35	24.25	24.45	24.95
210	7643	168	36.20	36.35	37.80	38.10	38.85

3 Results and Discussion

3.1 Engine/Propeller Parameters

With an increase in engine speed, the torque and effective shaft power increase as well (Table 4). Fuel consumption increases with an increase in the biodiesel share of the fuel (Table 4), which is due to the lower calorific value of biodiesel compared to diesel fuel.

3.2 Exhaust Emission

3.2.1 Oxides of Nitrogen, NOx

Different types of oxide of nitrogen (NOx) are produced when oxygen reacts with nitrogen in air and fuel at high temperatures (Heywood 1988). This means that the formation of NOx inside an engine cylinder is temperature dependent.

It can be observed from Figs. 3 and 4 that the amount of NOx increases with an increase in engine speed. The reason is very simple, i.e., the engine combustion temperature increases due to the increase in engine speed. The trend for the increase in NOx is smooth.

Emission of NOx from a biodiesel blend-fueled engine is significantly lower than the NOx emission from a diesel-fueled engine, at all engine speeds. This reduction ranges from 26 to 60%, and increases with increased biodiesel content in fuels and engine speed. Considering only blended fuels, with an increase in biodiesel content from 7 to 25%, there is evident NOx emission reduction regardless of engine speed. Possible reasons for the decrease in NOx are higher cetane numbers and a lower aromatic content of the biodiesel blends compared to the diesel fuel.

A higher cetane number in the biodiesel is usually associated with lower NOx emissions (Kalligeros et al. 2003; Monyem and Gerpen 2001). A higher cetane number reduces the ignition delay due to the reduced size of the premixed combustion. Reduced ignition delay results in lower NOx rates, since the combustion pressure rises more slowly, thus giving more time for cooling through heat transfer

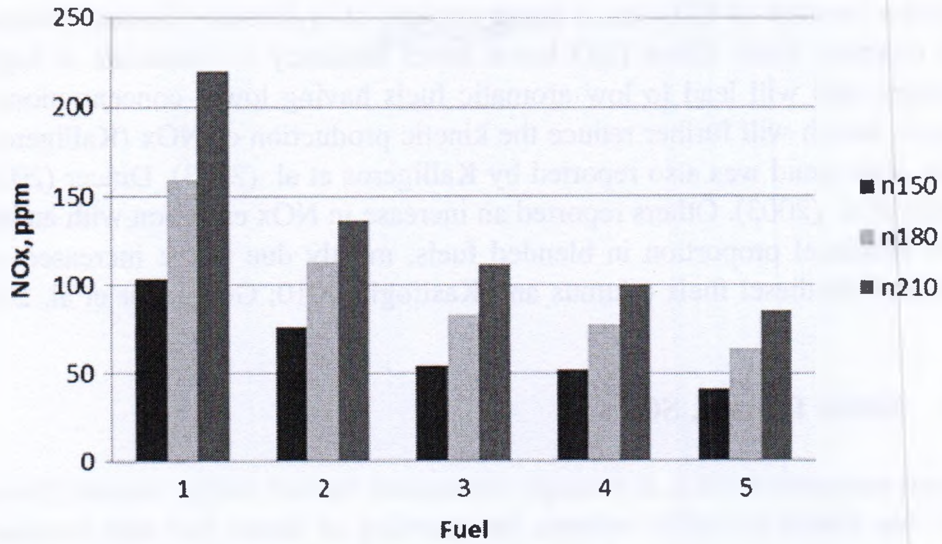

Fig. 3 Exhaust emission of NOx for different fuels, %

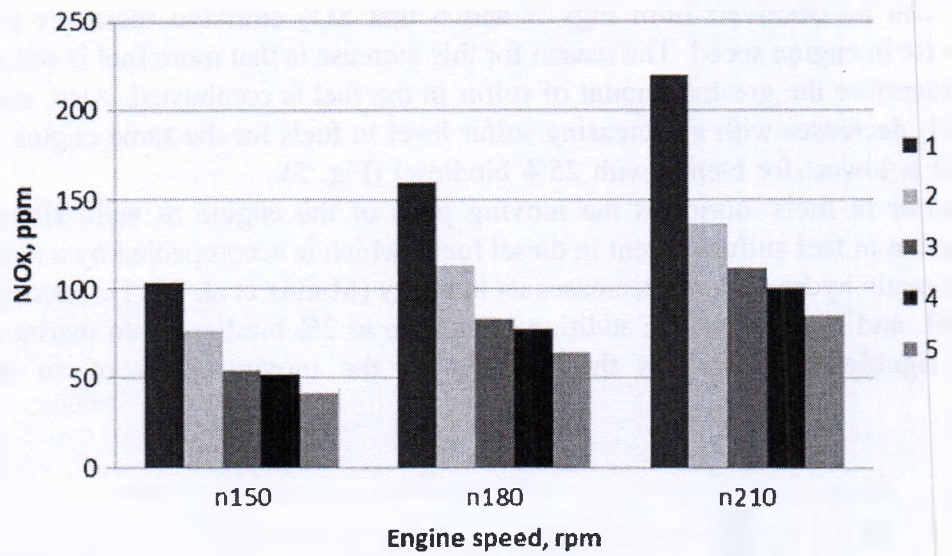

Fig. 4 Exhaust emission of NOx for different engine speeds, %

and dilution, and leading to the lower local gas temperatures (Kalligeros et al. 2003; Lee et al. 1998).

Furthermore, aromatic and poly-aromatic hydrocarbons are responsible for higher NOx emissions (Kalligeros et al. 2003; Takahashi et al. 2001; Spreen et al. 1995; Martin et al. 1997). This could be due to the higher flame temperatures associated with aromatic compounds. In reducing the aromatic and poly-aromatic content of the fuel, the flame temperature will be reduced as well, leading to a lower NOx production rate. Since biodiesel does not contain the above classes of compounds, its addition will reduce NOx emissions from the engines. The aromatics have high carbon–hydrogen ratios, and thus fuels with lower aromatics will lead to a smaller amount of CO_2 and a larger amount of H_2O being formed compared to high aromatic fuels. Since H_2O has a lower tendency to dissociate at high temperatures, this will lead to low aromatic fuels having lower concentrations of $O^{\bullet}$ radicals, which will further reduce the kinetic production of NOx (Kalligeros et al. 2003). This trend was also reported by Kalligeros et al. (2003), Dincer (2008) and Dorado et al. (2003). Others reported an increase in NOx emission with an increase in the biodiesel proportion in blended fuels, mostly due to the increased oxygen content of biodiesel fuels (Gumus and Kasifoglu 2010; Godiganur et al. 2010).

3.2.2 Sulfur Dioxide, SO_2

Exhaust emission of SO_2 is strongly dependent on fuel sulfur content. Since biodiesel has almost no sulfur content, the blending of diesel fuel with biodiesel can reduce the sulfur content, and thus reduce the emission of SO_2. The diesel fuel used in this experiment was the standard low sulfur diesel fuel used for naval vessels in Montenegro (Table 3).

It can be observed from Figs. 5 and 6 that SO_2 emission increases with an increase in engine speed. The reason for this increase is that more fuel is consumed, and therefore the greater amount of sulfur in the fuel is combusted. Also, emission of SO_2 decreases with a decreasing sulfur level in fuels for the same engine speed, and it is lowest for blends with 25% biodiesel (Fig. 5).

Sulfur in fuels lubricates the moving parts of the engine as well. Hence, the reduction in fuel sulfur content in diesel fuels, which is accompanied by a reduction in aromatic hydrocarbons, decreases its lubricity (Muñoz et al. 2011). According to (NREL and DoE 2009), the addition of as little as 2% biodiesel into marine diesel fuel significantly improves the lubricity of the moving parts of an engine.

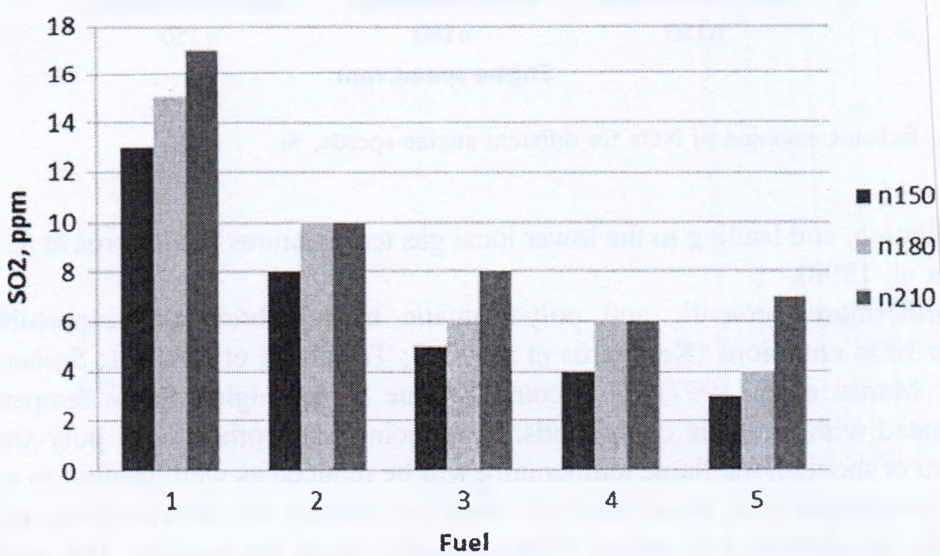

Fig. 5 Exhaust emission of SO_2 for different fuels, %

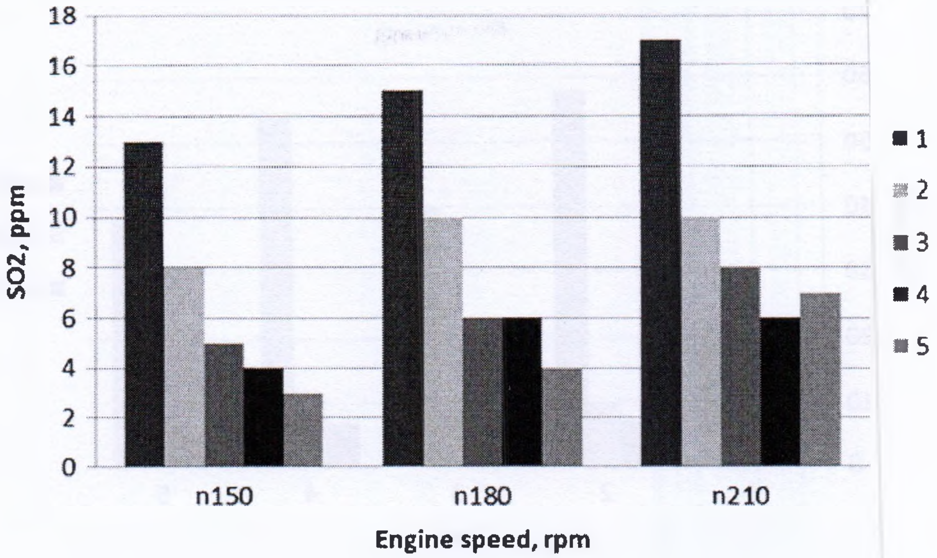

Fig. 6 Exhaust emission of SO_2 for different engine speeds, %

Therefore, adding biofuels into diesel fuel improves both SO_2 emission and fuel lubricity, the latter being very important for older two-stroke slow speed engines using low sulfur fuels, such as the engine used in this experiment.

3.2.3 Carbon Monoxide, CO

In an engine, CO emissions are controlled primarily by the air/fuel ratio. For fuel rich mixtures, CO emission increases steadily with a decrease in the air/fuel ratio, as the amount of fuel increases. For fuel lean mixtures, CO emission varies little with the air/fuel ratio. However, diesel engines always operate on the leaner side of the stoichiometric (Bhardwaj and Abraham 2008).

It can be observed from Figs. 7 and 8 that CO emission increases with an increase in engine speed. The reason for this increase is air/fuel ratio reduction with an increase in the load. Similar trends were reported by Gumus and Kasifoglu (2010), Usta et al. (2005) and Lertsathapornsuka et al. (2008).

Furthermore, emission of CO from a biodiesel-fueled engine is lower by more than 50% than that of a diesel-fueled engine at low and medium engine speeds. Considering only biodiesel blends, with an increase in biodiesel content from 7% to 25%, there is a reduction in CO emission regardless of engine speed, being most evident at maximum engine speed. This might be possible because of the oxygenated nature of biodiesel fuel. With biodiesel, owing to the inbuilt oxygen, the local air/fuel ratio during the combustion process becomes leaner, which results in the reduction in CO. This trend was also reported by Gumus and Kasifoglu (2010), Ramadhas et al. (2005). However, when applying maximum engine speed, there is notable increase in emitted CO when using biodiesel blends. At this high engine speed, poor combustion and other fuel characteristics annul the influence of

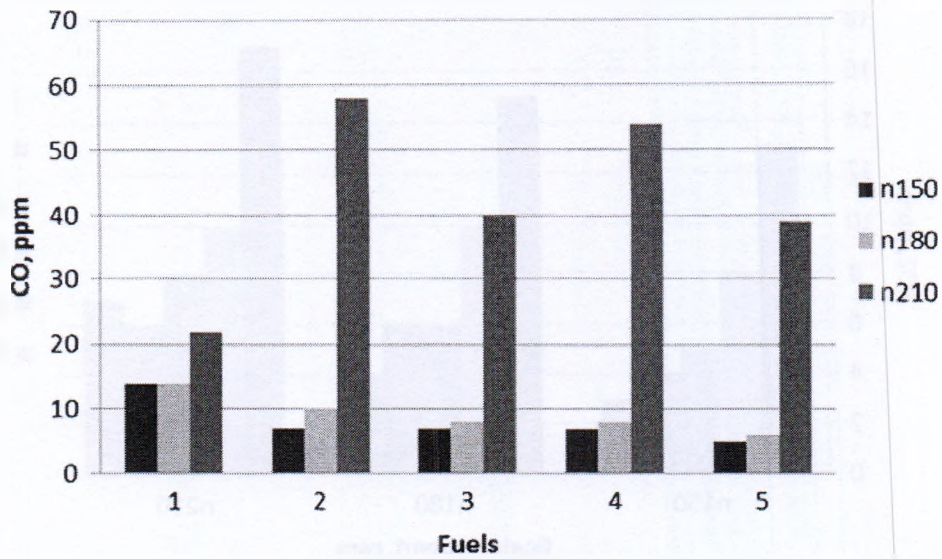

Fig. 7 Exhaust emission of CO for different fuels, %

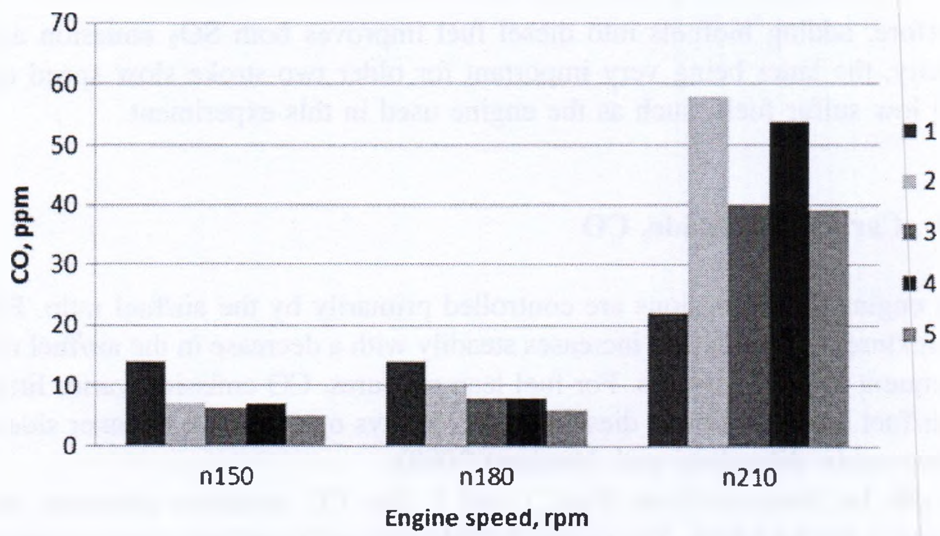

Fig. 8 Exhaust emission of CO for different engine speeds, %

biodiesel's higher oxygen content. This trend was also reported by Lujan et al. (2009), Fontaras et al. (2009).

3.2.4 Carbon Dioxide, CO_2

It can be observed from Figs. 9 and 10 that CO_2 emission increases with an increase in engine speed. The reason for this increase is that more fuel is consumed for higher power.

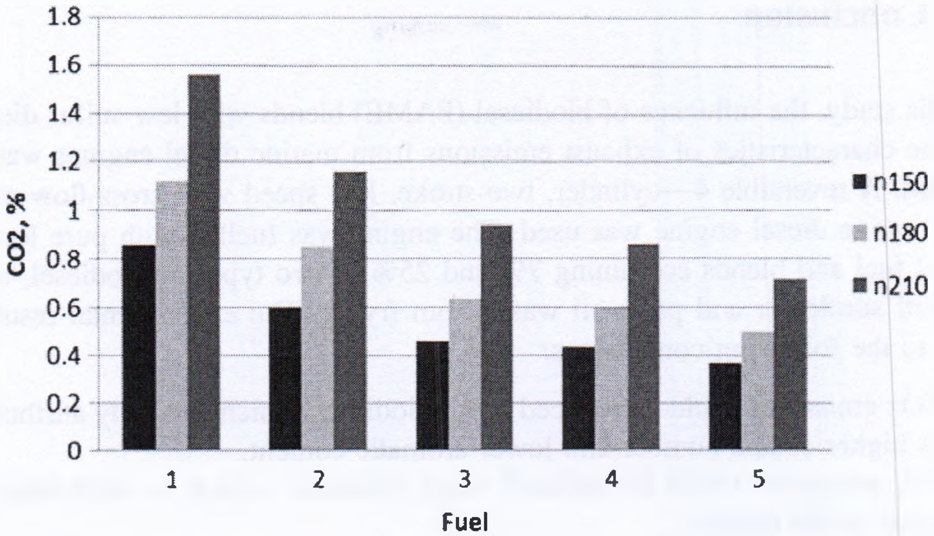

Fig. 9 Exhaust emission of CO_2 for different fuels, %

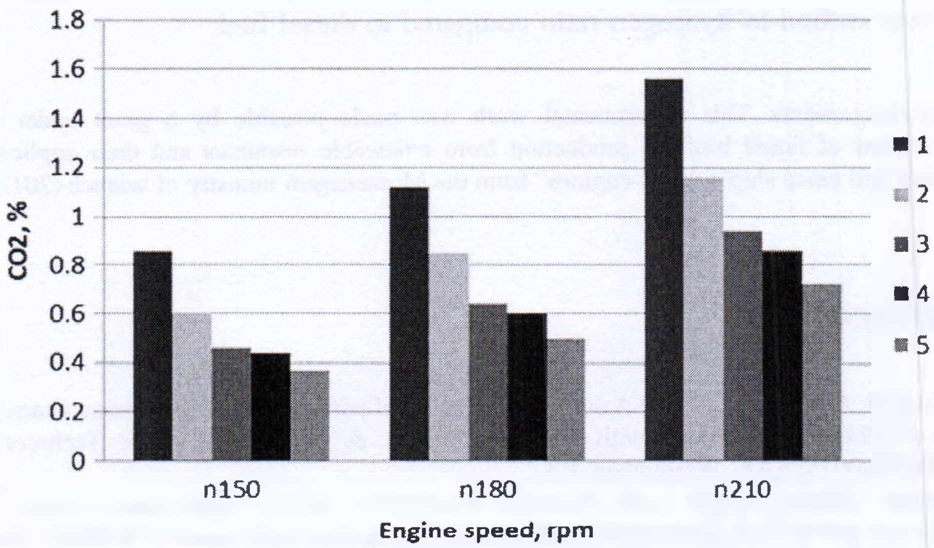

Fig. 10 Exhaust emission of CO_2 for different engine speeds, %

Emission of CO_2 from a biodiesel-fueled engine is lower than that from a diesel-fueled engine for a range of engine speeds, and this reduction is larger with biodiesel content in blends. The reason is that biodiesel blends have a lower carbon-to-hydrogen ratio than diesel fuel, and hence the combustion of these fuels produces less CO_2. This trend was also reported in Ozsezen et al. (2009), Utlu and Kocak (2008).

4 Conclusion

In this study, the influence of biodiesel (FAME) blends with low sulfur diesel fuel on the characteristics of exhaust emissions from marine diesel engines was investigated. A reversible 4—cylinder, two-stroke, low speed with cross-flow scavenging, marine diesel engine was used. The engine was fuelled with pure low-sulfur diesel fuel and blends containing 7% and 25% of two types of biodiesel, made of cast-off sunflower and palm oil waste from frying. The experimental results may lead to the following conclusions:

- NOx emissions could be reduced using biodiesel, which is mostly attributable to its higher cetane number and lower aromatic content.
- SO_2 emissions could be reduced using biodiesel, which is attributable to its lower sulfur content.
- CO emissions could be reduced using biodiesel, which is mostly attributable to its oxygenated nature, which makes for leaner combustion.
- CO_2 emissions could be reduced using biodiesel, which is attributable to its lower carbon-to-hydrogen ratio compared to diesel fuel.

Acknowledgements This experimental work was made possible by a grant under the title "Possibilities of liquid biofuels production from renewable resources and their application for merchant and naval ship's diesel engines" from the Montenegrin ministry of science (2012–2016).

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APPLICATION OF BIODIESEL DERIVED FROM OLIVE OIL PRODUCTION WASTES AT MARINE DIESEL ENGINE AND EVALUATION OF GASSEOUS EMISSION TRENDS

by

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Original scientific paper
https://doi.org/10.2298/TSCI220707218M

As a carbon neutral fuel, biodiesel is one option in future IMO scenarios for reducing carbon intensity in shipping sector, and at same time reducing emission of pollutants. Some oily wastes, such as waste from olive oil production, might be used for production of second-generation biodiesel. The current study looks into the effect of biodiesel on the characteristics of gaseous pollutant emissions of NO_x and CO from slow-speed two-stroke marine Diesel engines that do not have any after-treatment devices or engine control technology installed to reduce gaseous pollutant emissions. While the ship was berthed in the harbor, tests were performed on two separate loads at 210 rpm. The engine was powered by diesel fuel and blends of 7%, 20%, and 25% v/v of biodiesel derived from oily wastes generated during olive oil processing. For biodiesel production in lab conditions, base-catalyzed transesterification was implemented. According to the findings, there are tendencies of reduced gaseous emissions when utilizing blended fuels.

Key words*: biodiesel made of wastes from olive oil production, marine Diesel engine, gaseous pollutants*

Introduction

Total maritime transport sector has increased its CO_2 (GHG) emission from 962 million tonnes in 2012 to 1056 million tonnes in 2018, or from 2.76% in 2012 to 2.89% in 2018 of total anthropogenic global emission [1]. During same period, the carbon intensity of shipping operations decreased by around 11%, although efficiency gains were outpaced by increased activity [1].

Aside from GHG emission, maritime transport sector releases significant amounts of pollutants such as NO_x and SO_x, and in smaller amount CO and HC, as well. From 2014 to 2018, NO_x emissions climbed from 19 million tons to 20.9 million tons, while SO_x emissions increased from 10.2 million tons to 11.3 million tons, according to statistics [2].

The International Maritime Organization (IMO) regulates shipping air pollution and greenhouse gas emissions through MARPOL and Annex VI of the International Convention

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for the Prevention of Pollution from Ships. The Convention's Annex VI sets limits on NO_x and SO_x emissions from ship exhausts, prohibits deliberate emissions of ozone-depleting substances, regulates shipboard incineration and emissions of volatile organic compounds from tankers, and specifies variety of measures for improving the energy efficiency of new and existing ships (EEDI and SEEMP) [3]. In 2018, the IMO developed the strategy for reducing GHG emissions from ships [4]. The initial GHG strategy calls for a reduction in international shipping's carbon intensity (to reduce CO_2 emissions per transport work, as an average across international shipping, by at least 40% by 2030, with a goal of 70% by 2050, compared to 2008) and a reduction in total annual GHG emissions from international shipping of at least 50% by 2050, compared to 2008. An updated strategy is set to be released in 2023 [4]. Over the next few decades, policy changes and stakeholder participation will push ship owners to find, evaluate, and adopt technology, fuels, and solutions that help them decarbonize their ships, cut energy use, and meet other environmental goals. The need for decarbonization in global industrial value chains will also drive logistics optimization, including measures like greater fleet utilization and speed reductions [5].

While the particular solutions available to different ship segments may differ, decarbonization of shipping will necessitate the use of carbon-neutral fuels to replace fossil fuels. A range of energy sources or energy systems that have no net GHG emissions or carbon footprint are referred to as carbon-neutral. Sustainable biofuels may be a good fit for replacing oil-based fuels in the existing ship fleet. Hydrogenated vegetable oil, biomass-to-liquids, and fatty acid methyl ester (FAME) are all types of biofuels. The FAME is not a drop-in fuel because the international standard ISO 8217:2017 limits the allowed blending concentration at 7%. Still, the IMO study concludes that low blends of biodiesel of up to 20% (B20) could be used without any fuel system modifications [6].

Biodiesel is a long-chain fatty acid mono-alkyl ester made from animal fats or vegetable oils. The most common way of manufacturing biodiesel is by an esterification reaction [7]. As a catalyst, a short-chain alcohol such as methanol (or acid or base) is used in the reaction [7].

The main disadvantages of biofuels are a scarcity of raw materials and high production costs. Because biodiesel is derived from animal fats or vegetables, its use is controversial due to food competition. Using oils from waste materials is a viable strategy for lowering the cost of raw materials for biodiesel production without competing with food.

Although practical experience with the use of biodiesel in the shipping industry is very scarce [7], several research activities [2, 7-9] and demonstration projects [10, 11] have been conducted to assess the technical feasibility of different biofuels.

The aim of this study was to produce biodiesel from local wastes and use it as fuel for marine Diesel engines. It was followed by characterizing the biodiesel properties and comparatively assessing the effects of diesel and biodiesel blends on diesel engine performance and exhaust emission trends under various loads. For the study, a reversible two-stroke, low-speed, cross-flow scavenging, four-cylinder marine Diesel engine was used. The engine was fuelled with pure diesel fuel and blends containing 7%, 20%, and 25% of the biodiesel produced in laboratory conditions using oily wastes from olive oil extraction. Base-catalyzed transesterification was implemented for biodiesel production.

Experimental procedure

A marine Diesel engine was used in this experiment. It was a reversible two-stroke, four-cylinder marine Diesel engine with cross-flow scavenging, type ALPHA 494 R, manufactured under Burmeister license by LITOSTROJ Ljubljana, Slovenia, tab. 1. The engine is classified as a low-speed engine because its maximum speed is 320 rpm and it produces 390 kW of power. Because it was an old-style marine Diesel engine, no after-treatment devices or engine management systems to limit pollutant emissions were fitted. In fact, a circumstance like this is ideal for studying the direct effects of biodiesel on exhaust emissions from marine Diesel engines. After the last overhaul, the engine has been operating for 8600 hours with no alterations made for this experiment.

Table 1. Marine Diesel engine specifications

Engine producer	Engine model	Working principle	Max power	Cylinder No.	Stroke/Bore
Burmeister	Alpha 494-R	two-stroke	390 kW at 320 rpm	4	490 mm/290 mm

The direct propulsion system of the ship comprises of the engine, propeller shaft connected to the output coupling, and a fixed-pitch propeller. Tests were conducted when the ship was berthed in harbour and during the same day – in order to have the identical atmospheric conditions. At the engine crankshaft speed of 210 rpm, two modes of load were achieved, the first with the rudder in the zero position (midship) and the rudder turned to the far left, which achieves an increased load for the same number of revolutions (designated as 210 and 210N, respectively).

During the engine operation, power is constantly changing depending on the connected consumer. In the conditions of operation of the vessel, engine power that is transmitted to the fixed pitch-propeller depends on the number of revolutions, pitch and propeller diameter. Effective power that is delivered to the propeller could be expressed via the torque which is transmitted from the engine crankshaft, via coupling, to the propeller shaft and propeller, where it reverses the angular velocity, ω. The recorded average torque and shaft speed data can be used for engine effective power estimation in accordance to the formula below [12]:

$$P_e = M\omega = \frac{M\pi n}{30} \text{ [kW]} \tag{1}$$

where M [kNm] represents measured torque [kNm] and n [rpm] represents engine-propeller rotational speed .

As for the set of engine speeds and different testing fuels, measurements of propeller shaft torque and power were conducted by means of strain gauges. This method establishes a functional connection between the elastic angular deformation of the propeller shaft and engine torque/power. Measurements of the propeller shaft torque and power were conducted by installing two pairs of strain gauges (type XY21-6/350), connected in Wheatstone bridge, onto the propeller shaft. The strain gauges were mounted at an angle of 180° relative to one another. Power was delivered to strain gauge from a 9 V source. Measuring signal from the Wheatstone bridge was delivered to the radio transmitter, allowing transfer of data to the receiver. A power source, transmitter and antenna were mounted on a ringed disc made of plastic, placed on the propeller shaft, with a view to eliminate noise. Next to the shaft, a signal receiver and a speed sensor were placed, fig. 1. The signal receiver and the speed sensor were connected to an electronic measuring device – Spider 8. The

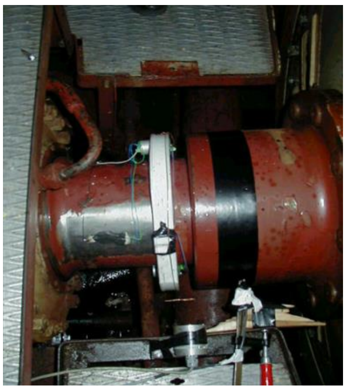

Figure 1. Strain gauges mounted on the propeller shaft

Spider 8 was connected to a personal computer. The software for data processing was *Catman 3.0*. The equipment listed was produced by hottinger baldwin messtehnik.

Fuel consumption (FC) was measured directly during experiment, while the brake specific fuel consumption (BSFC), and brake thermal efficiency (BTE) were calculated based on the known equations.

The hourly fuel consumption was measured for each engine speed and fuel type. The volumetric method of fuel consumption measurement was employed for fuel mass-flow estimation according [12]:

$$FC = \frac{V_f \rho_f}{t} \tag{2}$$

where FC [kgh^{-1}] represents fuel mass-flow, V_f [m^3] represents fuel volume consumed during the measurement time, ρ_f [kgm^{-3}] represents fuel density, and t [hours] represents the time period of measurement.

The BSFC [gr per kWh] is defined as the ratio of fuel mass-flow to the engine power. It is calculated by [13]:

$$BSFC = \frac{m_f 10^3}{P_e} \tag{3}$$

where m_f [kgh^{-1}] is the fuel consumption and P_e [kW] – the engine power.

The BTE [%] is the ratio of engine power to the thermal energy released by fuel combustion under unit of time. It is calculated by [7]:

$$BTE = \frac{P_e 3600}{m_f H_d} 100 \text{ [\%]} \tag{4}$$

where m_f [kgh^{-1}] is the fuel consumption, P_e [kW] – the engine power, and H_d [kJkg^{-1}] – the lower heating value of the tested fuel.

Exhaust emission analyser Testo, model 350-MARITIME, was used in the experiment for measuring gaseous concentrations in the engine exhaust. Testo model 350-MARITIME has Germanischer Lloyd (DNV GL) and Nippon Kaiji Kyokai (Class NK) certificates according to MARPOL Annex VI and NOx Technical Code 2008 [14]. The specifications of the emissions analyzer are cited in tab. 2. The instrument itself was located on the engine room's gallery, about two meters above the engine. The probe was inserted into an opening in the exhaust gases collector above the engine (which was designed for such experiments). The lower section of the exhaust gasses collector from the engine exhaust to the point of probe insertion was not cooled. Once the engine parameters were stabilized, the exhaust emission measurements were performed for each engine's speed regime for the same exhaust gas flow. Each running step was held for 10 minutes until exhaust emissions were stabilized and maintained while each parameter was measured and recorded, during the last 5

Table 2. Specification of exhaust emission analyser Testo, model 350-MARITIME [14]

Parameter	Measuring range	Accuracy
°C, flue gas	–40 up to 1000 °C	max ±5K
O_2	0 … 25 vol.%	According to to MARPOL Annex VI and NO_x technical code
CO	0 … 3000 ppm	
NO	0 … 3000 ppm	
NO_2	0 … 500 ppm	
SO_2	0 … 3000 ppm	
CO_2	0 … 40 vol.%	
Pabs	600 … 1150 hPa	±5 hPa at 22 °C ±10 hPa at –5 °C up to 45 °C

minutes of each running step. Measurements were taken on the same day to ensure that the atmospheric conditions were nearly identical in each test. Figure 2 depicts the exhaust emission test schematic.

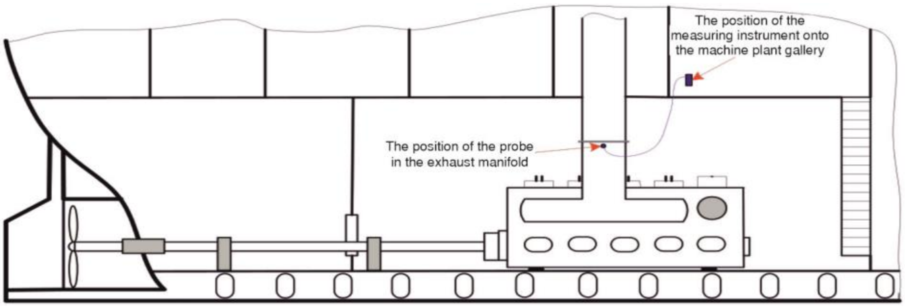

Figure 2. The position of exhaust emission testing equipment

An outside tank supplied fuel to the engine. The fuel lines were cleaned after each fuel type change, and the engine was left running for at least 20 minutes to stabilize under the new conditions. Separate fuel samples were prepared and poured into separate tanks that were connected to the suction side of the engine fuel pump. Excess fuel was pumped back into the same tank. The tanks were placed on the gallery in the engine room, about 2 m above the engine, so that the fuel was delivered to the fuel pump by gravity. In addition, a glass burette of known volume was attached to the tank and used to measure fuel consumption.

Given that the marine Diesel engine was running for 8600 hours after the last overhaul and that there were no adjustments of the engine for this experiment, the purpose of performed measurements was to give trends of gaseous emissions in relation to different types and content of the second-generation biodiesel in the blends for the marine diesel engine in service.

Results and discussion

Test fuel parameters

The engine was powered by diesel fuel and blends containing 7%, 20%, and 25% v/v of the FAME. None of the blends required any adjustments to the marine Diesel engine for this experiment [5]. The diesel fuel was a typical fuel used by the Montenegrin fleet in territorial waters, with a flash point above 60 °C. The FAME was produced in the lab conditions using oily wastes from olive oil extraction (olive pomace) collected from Montenegro's local olive oil producers. The FAME was produced using base-catalyzed transesterification. Table 3 shows the basic test fuel properties, with letter D representing pure diesel fuel with no biodiesel addition, DO representing blends of diesel fuel and biodiesel made of olive pomace oil. In the case of blended fuels, a percentage of biodiesel in the blend is added to the initial letters. Because the tests were carried out during the summer, the poor low temperature properties of biodiesel were avoided.

Table 3. Test fuels basic properties

Parameters	Units	D	DO7%	DO20%	DO25%
Density at 15 °C	kg/m^3	833.4	837.8	846.1	849.2
Viscosity at 40 °C	mm^2/s	2.92	3.02	3.21	3.28
Cetane number	–	51.3	53.8	55.1	55.4
Sulfur content	mg/kg	8.6	8.0	7.1	6.7
Total aromatics	% m/m	22.8	21.2	18.2	17.1
Lower heating value	MJ/kg	43.98	43.41	42.34	41.93
FAME content	v/v	0	7	20	25

Engine parameters

The FC, BSFC, and BTE at each operation condition are further discussed.

With an increase in engine speed, torque and effective shaft power increased as well, as shown in tab. 4. For the constant engine parameters, fuel consumption increased along with the increase in biodiesel share in the blends, as shown in tab. 4, which is due to lower calorific value of biodiesel compared to diesel fuel.

Table 4. Dependence of engine speed on torque, effective power, and fuel consumption

Engine speed [rpm]	Torque [Nm]	Effective power (propeller), [kW]	Fuel consumption, [kgh^{-1}]			
			D	DO7	DO20	DO25
n210	7643	168	36.20	37.2	38.1	38.65
n210N	8371	184	38.60	39.95	41.05	41.45

As it can be observed, biodiesel blends have greater fuel consumption and BSFC than diesel fuel under the same engine operation circumstances, fig. 3. Furthermore, when the biodiesel blended ratios grow, so does the fuel consumption and BSFC. The fundamental reason is that biodiesel and consequently fuel mixes have a lower heating value than pure diesel fuel. Some studies have also stated that the decrease in biodiesel fuel heating value is the most significant component resulting in enhanced BSFC for biodiesel fuels [2, 7]. As a result, in order to maintain the same engine output under the same conditions, the fuel injection volume is increased in fuel blended mode, resulting in an increase in FC and BSFC.

Viscosity and density, in addition to the heating value, have important roles in raising BSFC [7]. Biodiesel has a greater viscosity, it has a lower fluidity, which might cause pressure oscillations in the fuel supply pipeline at low temperatures. At low-load engine operations, this might result in poor atomization during combustion resulting in partial combustion. Because of the increased in-cylinder temperature, the influence of kinematic viscosity on BFSC may progressively diminish as the engine load increases.

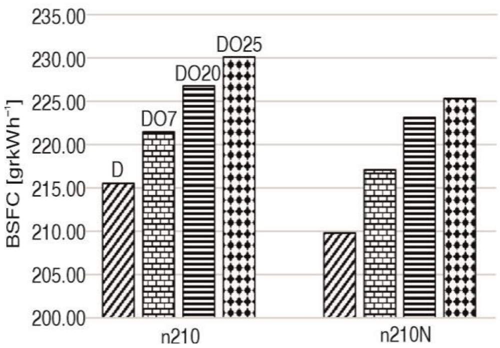

Figure 3. The BSFC for diesel fuel and biodiesel blends with different engine load conditions

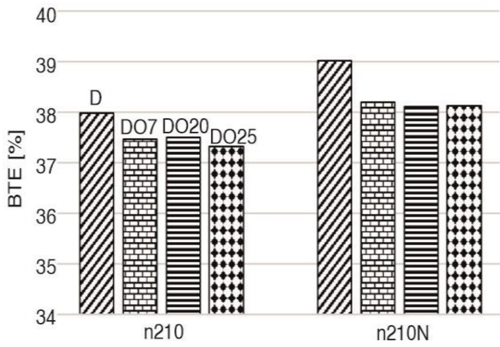

Figure 4. The BTE for diesel fuel and biodiesel blends with different engine load conditions

The BTE rises as engine speed and load increases, although it has minimal association with biodiesel blend ratios. In comparison to diesel fuel, the oxygenated character of biodiesel aids in the improvement of the combustible mixture and the promotion of complete combustion. However, in terms of BTE performance, incomplete combustion due to poor atomization and low calorific value of biodiesel blends have a larger influence in the reduction of BTE. Similarly, [2, 7] achieved comparable findings, fig. 4.

Exhaust emission

Carbon monoxide

Diesel engines always operate with fuel lean mixtures [15]. In this case, CO concentration in the exhaust varies little with the air/fuel ratio [15].

Figure 5 shows that CO emission concentrations rose as engine loads increased due to a drop in air/fuel ratio. In addition, with increasing engine speeds and loads, more fuel has being injected. In works of [7, 13, 16-18] similar patterns was shown.

There is a trend of decreasing CO emissions with increasing biodiesel content in test fuels. This is feasible due to the oxygenated nature of biodiesel fuel. When biodiesel blends are used, the local air/fuel ratio increases during combustion, resulting in lower CO emissions from biodiesel blends. [7, 13] reported on this tendency.

The greater likelihood of being converted to CO_2 resulted in a reduction in CO emissions [7]. Furthermore, because biodiesel fuel has lower carbon content than diesel fuel, it emits less carbon oxides.

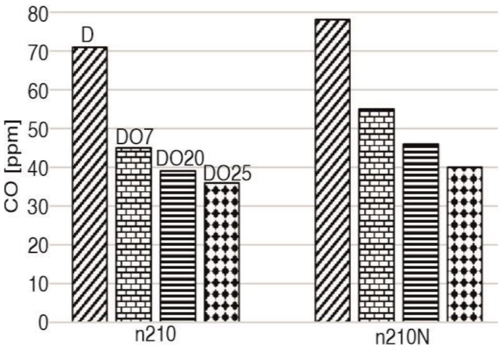

Figure 5. Exhaust emission of CO for different fuels and engine loads, [ppm]

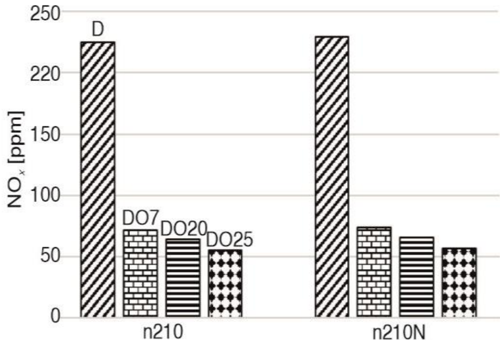

Figure 6. Exhaust emission of NO_x for different fuels and engine loads, [ppm]

Oxides of nitrogen

It can be observed from fig. 6 that the amount of NO_x slightly increased with an increase in engine load. The reason for this is a higher combustion temperature, because NO_x generation inside engine cylinders is temperature-dependent [19].

At both engine loads, there is a trend of decreasing NO_x emissions with increasing biodiesel content in test fuels, fig. 6. Higher cetane numbers and lower aromatic concentrations in biodiesel blends compared to diesel fuel might be explanations for NO_x reduction. In literature, higher cetane levels in biodiesel blends are typically linked with reduced NO_x emissions when compared to diesel fuel [13, 20, 21]. Higher cetane number reduces the size of the premixed combustion by shortening the ignition delay, resulting in lower NO_x formation rates as the combustion pressure rises more slowly, allowing more time for cooling via heat transfer and dilution and resulting in lower localized gas temperatures [20, 22].

Aromatic and poly-aromatic hydrocarbons, in particular, are responsible for increased NO_x emissions [20, 23-25]. This is most likely because aromatic compounds produce greater flame temperatures. By lowering the aromatics, the flame temperature falls, resulting in a decreased NO_x generation rate. As a result, adding biodiesel, which does not include aromatic compounds, reduces NO_x emissions from engines. Because aromatics have a high carbon-hydrogen ratio, fuels with lesser aromatics produce less CO_2 and more H_2O when compared to highly aromatic fuels. Since H_2O has a lower tendency to dissociate at high temperatures (compared to CO_2), this leads to low aromatic fuels having lower concentrations of $O^{\bullet}$ radicals, which further reduces the kinetic production of NO [20]. The same trend was also reported by [20, 26, 27].

According to [2], decreased NO_x emissions with biodiesel might be attributed to its lower fuel nitrogen concentration and lower mean in-cylinder temperature.

Others reported an increase of NO_x emission with an increase in biodiesel proportion in blended fuels owing to the increasing oxygen content of biodiesel fuels [8, 16, 28].

Conclusion

The effect of biodiesel (FAME) generated from oily wastes following olive oil manufacturing on the characteristics of gaseous emissions from a slow-speed, two-stroke marine Diesel engine was studied. The engine was run on pure low sulfur diesel fuel as well as blends comprising 7%, 20%, and 25% of such biodiesel. The findings might lead to the following conclusions.

- Biodiesel blends have greater fuel consumption and BSFC than pure diesel fuel under the same engine operation circumstances due to its lower heating value and increased injection volume for the same engine output. At low loads, higher viscosity of biodiesel blends might result in poor atomization. With increasing load, influence of viscosity is diminished due to increased in-cylinder temperature.
- The BTE rises as engine speed and load increase, although it has minimal association with biodiesel blend ratios.
- There is a tendency toward lower CO emissions with increasing biodiesel content in blended fuels, which might be attributed to their oxygenated nature, which results in leaner combustion.
- There is a tendency toward lower NO_x emissions with increasing biodiesel content in blended fuels, which might be attributed to their greater cetane number and reduced aromatic content of blended fuels, offsetting their oxygenated nature in this particulate engine.

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Paper submitted: July 7, 2022
Paper revised: August 24, 2022
Paper accepted: September 21, 2022

Brodogradnja/Shipbuilding/Open access Volume 67 Number 4, 2017

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http://dx.doi.org/10.21278/brod67406 ISSN 0007-215X
eISSN 1845-5859

EVALUATION OF POLLUTANT EMISSIONS FROM TWO-STROKE MARINE DIESEL ENGINE FUELED WITH BIODIESEL PRODUCED FROM VARIOUS WASTE OILS AND DIESEL BLENDS

UDC 621.436:.13:665.753:536.46:519.6:629.5.016.8:629.5(05)
Original scientific paper

Summary

Shipping represents a significant source of diesel emissions, which affects global climate, air quality and human health. As a solution to this problem, biodiesel could be used as marine fuel, which could help in reducing the negative impact of shipping on environment and achieve lower carbon intensity in the sector. In Southern Europe, some oily wastes, such as wastes from olive oil production and used frying oils could be utilized for production of the second-generation biodiesel. The present research investigates the influence of the second-generation biodiesel on the characteristics of gaseous emissions of NOx, SO_2, and CO from marine diesel engines. The marine diesel engine that was used, installed aboard a ship, was a reversible low-speed two-stroke engine, without any after-treatment devices installed or engine control technology for reducing pollutant emission. Tests were carried out on three regimes of engine speeds, 150 rpm, 180 rpm and 210 rpm under heavy propeller condition, while the ship was berthed in the harbor. The engine was fueled by diesel fuel and blends containing 7% and 20% v/v of three types of second-generation biodiesel made of olive husk oil, waste frying sunflower oil, and waste frying palm oil. A base-catalyzed transesterification was implemented for biodiesel production. According to the results, there are trends of NOx, SO_2, and CO emission reduction when using blended fuels. Biodiesel made of olive husk oil showed better gaseous emission performances than biodiesel made from waste frying oils.

Key words: Olive husk oil; Waste frying oils; Biodiesel; Two-stroke marine diesel engine; Gaseous emission

1. Introduction

The shipping sector has become a key component of the world's economy. The world fleet of seagoing merchant ships comprises over 104,000 ships [1]. At the same time, on an annual average basis (2007–2012), ships account for 13%, and 15% of global sulfur oxide (SOx) and nitrogen oxides (NOx), respectively [2]. Shipping air pollution is regulated by

IMO, through its International Convention for the Prevention of Pollution from Ships, MARPOL, and Annex VI. Annex VI to the Convention sets limits on NOx and SOx emissions from ship exhausts, prohibiting deliberate emissions of ozone-depleting substances and regulating shipboard incineration and emissions of volatile organic compounds (VOC) from tankers [3].

As a renewable energy source, biofuels have a favorable impact on the environment and can partly replace fossil fuels. The main drawbacks of biofuels include limited raw materials and high production costs. Yet, biodiesel could be an option in reducing the emission of pollutants and greenhouse gasses in the shipping sector. Nowadays, however, the practical experience with the use of biodiesel in the shipping industry is very scarce. The implementation of biodiesel as marine fuel was tested in a few research programs, where some advantages of biodiesel over fossil fuels were noted [4], including the fact that blending can be made of up to 100% of biodiesel, that there is reduction of particulate emissions, no adverse effects detected in marine engines and no bacterial formations detected in biofuel tanks during six-month storage time [4]. However, the programs also noted potential problems reflected in the fact that biodiesel acts as a solvent and tends to soften and degrade certain rubber and elastomer compounds that are often used in older engines and that it can easily remove deposits remaining after the use of diesel fuel in the system, causing the filters to clog. Still, the IMO study concludes that low blends of biodiesel of up to 20% (B20) could be used without any fuel system modifications [5]. The aforementioned studies were conducted on four-stroke medium-speed marine diesel engines.

In this present study, the influence of biodiesel (FAME) and diesel fuel blends on the characteristics of exhaust emissions from marine diesel engine is investigated. For the study, a reversible two-stroke, low-speed, cross-flow scavenging, four-cylinder marine diesel engine was used. The engine was fueled with pure diesel fuel and blends containing 7% and 20% of the three types of biodiesel. The biodiesel was produced in laboratory conditions, using olive husk oil, waste frying sunflower oil and waste frying palm oil. Base-catalyzed transesterification was implemented for biodiesel production.

2. Experimental Procedure

For the present study, a marine diesel engine was employed. It was a reversible two-stroke, four-cylinder, marine diesel engine with cross-flow scavenging – model ALPHA 494 R produced by LITOSTROJ Ljubljana (Slovenia) under Burmeister license, Table 1. The engine can be regarded a low-speed one as the maximum engine speed is 320 rpm, while it produces the maximum power of 390 kW. Given that it is an old-type marine diesel engine, there were no after-treatment devices installed, nor was there engine control technology to reduce pollutant emissions. As a matter of fact, such a situation is preferable for investigation of direct influence of biodiesel on exhaust emission from marine diesel engines. Engine was running for 8,600 hours after the last overhaul and were no any adjustments of the engine for this experiment.

The direct propulsion system of the ship comprises of the engine, propeller shaft connected to the output coupling, and a fixed-pitch propeller. Tests were conducted when the ship was berthed in harbor and during the same day – in order to have the identical atmospheric conditions. Running the engine when the ship is berthed is called a heavy propeller condition. Tests were carried out on three regimes of engine speeds, 150 rpm, 180 rpm and 210 rpm.

Table 1 Marine diesel engine specifications

Engine producer	Engine model	Working principle	Max power	Cyl. No.	Stroke/Bore
Burmeister	Alpha 494-R	2-stroke	390 kW @ 320 rpm	4	490mm/290mm

During the engine operation, power is constantly changing depending on the connected consumer. In the conditions of operation of the vessel, engine power that is transmitted to the fixed pitch-propeller depends on the number of revolutions, pitch and propeller diameter. The resistance provided by a fixed-pitch propeller is proportional to the square of the propeller speed:

$$M = k \cdot n^2 \qquad (1)$$

Effective power that is delivered to the propeller could be expressed via the torque which is transmitted from the engine crankshaft, via coupling, to the propeller shaft and propeller, where it reverses the angular velocity ω. The recorded average torque and shaft speed data can be used for engine effective power estimation in accordance to the formula below [6]:

$$P_e = M \cdot \omega = M \frac{\pi \cdot n}{30} [kW] \qquad (2)$$

where:

M - represents measured torque [kNm],

n - represents engine-propeller rotational speed [rpm].

As for the set of engine speeds and different testing fuels, measurements of propeller shaft torque and power were conducted by means of strain gauges. This method establishes a functional connection between the elastic angular deformation of the propeller shaft and engine torque / power. Measurements of the propeller shaft torque and power were conducted by installing two pairs of strain gauges (type XY21-6/350), connected in Wheatstone bridge, onto the propeller shaft. The strain gauges were mounted at an angle of 180˚ relative to one another. Power was delivered to strain gauge from a 9 V voltage source. Measuring signal from the Wheatstone bridge was delivered to the radio transmitter, allowing transfer of data to the receiver. A power source, transmitter and antenna were mounted on a ringed disc made of plastic, placed on the propeller shaft, with a view to eliminate noise. Next to the shaft, a signal receiver and a speed sensor were placed. The signal receiver and the speed sensor were connected to an electronic measuring device – Spider 8. Spider 8 was connected to a personal computer. The software for data processing was “Catman 3.0”. The equipment listed was produced by Hottinger Baldwin Messtehnik (HBM).

The hourly fuel consumption was measured for each engine speed and fuel type. The volumetric method of fuel consumption measurement was employed for fuel mass flow estimation according to the following formula [6]:

$$B = \frac{V_p \cdot \rho_p}{t} [kg/h] \qquad (3)$$

where: B - represents fuel mass flow [kg/h],

V_p - represents fuel volume consumed during the measurement time [m^3],

ρ_p - represents fuel gravity [kg/m^3],

t - represents the time period of measurement [h].

In the experiment, an exhaust emission analyzer by Testo (model 350-MARITIME) was used to measure SO_2, CO, and NOx concentrations in the engine exhaust. The instrument itself was located on the gallery in the engine room, about two meters above the engine. The probe was posed into an opening of the exhaust gases collector (which was designed for such experiments) above the engine. A lower part of the exhaust gasses collector from the engine exhaust to the point of probe insertion was not cooled. The schematic of the exhaust emission tests is given in Figure 1. The exhaust emission measurements were conducted for each engine's speed regime, once the engine parameters were stabilized, for the same exhaust gases flow. Each running step was held for 10 minutes until exhaust emissions were stabilized and maintained while each parameter was measured and recorded, during the last 5 min of each running step. Measurements were conducted same day, in order to have almost the same atmospheric conditions within each test.

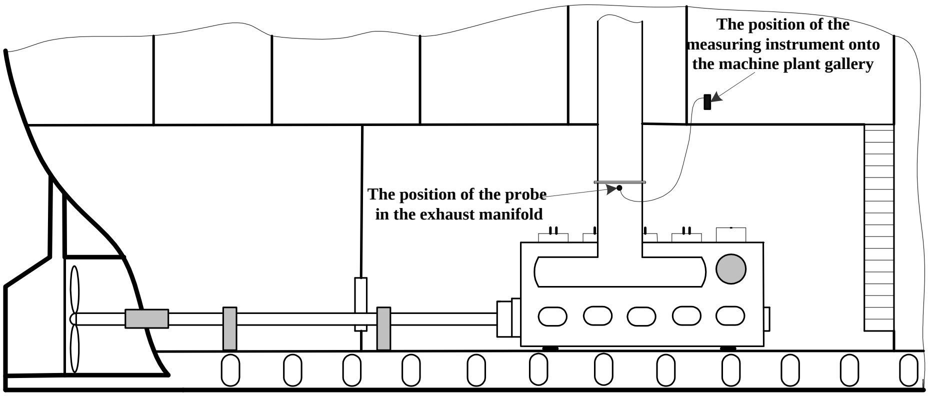

Fig. 1 The position of exhaust emission testing equipment

The engine was fueled with diesel fuel and blends containing 7% and 20% v/v of the three biodiesel types (FAME). Neither of the blends required adjustments of marine diesel engine [5]. The diesel fuel was a representative fuel used by the fleet of Montenegrin vessels in territorial waters with a flash point above 60 ºC. The three types of biodiesel were produced in lab conditions, using waste frying sunflower oil, waste frying palm oil and olive husk oil. Waste frying oils were collected from hotels and restaurants, whereas olive husk oil was collected from the local olive oil producers in Montenegro. Base-catalyzed transesterification was used for biodiesel production. Basic test fuel properties are given in Table 2, where letter D stands for pure diesel fuel without any biodiesel addition, DS for blends of diesel fuel and biodiesel made of waste frying sunflower oil, DP for blends of diesel fuel and biodiesel made of waste frying palm oil, and DO for blends of diesel fuel and biodiesel made of olive husk oil. For blended fuels, a percentage of biodiesel in blends is added to initial letters. The tests were conducted in the summer period, so poor low-temperature properties of biodiesel were avoided.

Fuel was supplied to the engine from an outside tank. For each fuel type change, the fuel lines were cleaned and the engine was left running for at least 20 minutes to stabilize under the new conditions. Fuel samples were prepared separately and poured into separate tanks connected to the suction side of the engine fuel pump. Excess fuel was returned into the same tank. The tanks were located on the gallery in the engine room about two meters above the engine, so the fuel is delivered to the fuel pump by the force of gravity. In addition, a glass burette of known volume was attached to the tank and was used for fuel consumption measurements.

Table 2 Test fuels basic properties

Parameters	Units	1 D	2 DS7%	3 DS20%	4 DP7%	5 DP20%	6 DO7%	7 DO20%
Density @ 15°C	kg/m^3	833.4	837.2	844.4	836.7	842.9	837.8	845.9
Viscosity @ 40°C	mm^2/s	2.92	2.95	3.12	3.00	3.19	3.31	3.46
Cetane number		51.3	53.5	54.9	52.5	54.1	53.8	55.1
Distillation								
% (v/v) recovered @ 250°C	% (v/v)	29	28	27	26	25	26	27
% (v/v) recovered @ 350°C	% (v/v)	91	91	89	92	92	91	89
95% (v/v)	°C	354	357	359	356	357	355	358
Sulfur content	mg/kg	8.6	7.8	6.2	7.9	6.1	7.8	6.0
Water content	mg/kg	40.94	79.99	153.42	71.93	128.23	56.52	111.44
Total aromatics	% m/m	22.8	22.3	20.3	22.5	20.9	22.4	20.3
FAME content	v/v	0	7	20	7	20	7	20

Given that the marine diesel engine was running for 8,600 hours after the last overhaul and that there were no adjustments of the engine for this experiment, the purpose of performed measurements was to give trends of gaseous emissions in relation to different types and content of the second-generation biodiesel in the blends for the marine diesel engine in service.

3. Results and Discussion

3.1 Engine Parameters

With an increase in engine speed, torque and effective shaft power increased as well, as shown in Table 3. For the constant engine parameters, fuel consumption increased along with the increase in biodiesel share in the blends, as shown in Table 3, which is due to lower calorific value of biodiesel compared to diesel fuel.

Table 3 Dependence of engine speed on torque, effective power and fuel consumption

Engine speed, rpm	Torque, Nm	Effective power (propeller), kW	Fuel consumption, kg/h						
			1 D	2 DS7%	3 DS20%	4 DP7%	5 DP20%	6 DO7%	7 DO20%
150	4267	67	15.30	16.00	16.10	15.30	15.70	15.85	16.05
180	5609	105	23.20	24.45	24.55	23.35	23.95	24.00	24.20
210	7643	168	36.20	38.10	38.25	36.35	37.30	37.40	37.75

3.2 Exhaust Emission

3.2.1 Oxides of Nitrogen, NOx

It can be observed from Figure 2 that the amount of NOx increased with an increase in engine speed. The reason for this is an increased combustion temperature, since the formation of NOx inside the engine cylinders is temperature-dependent [7].

The emission of NOx from a biodiesel blends fueled engine was significantly lower than the NOx emission from a diesel fueled engine, at all engine speeds. This reduction ranged from 26 % (in case of diesel fuel blended with biodiesel made of waste frying palm oil) to 72 % (in case of diesel fuel blended with biodiesel made of olive husk oil), and increased with an increase in biodiesel content in blends and engine speed. As regards blended fuels only, with an increase in biodiesel content from 7% to 20%, there was NOx emission reduction regardless of the engine speed. Possible reasons for NOx reduction are higher cetane numbers and lower aromatic contents of the biodiesel blends compared to diesel fuel. Higher cetane numbers of the biodiesel blends compared to that of the diesel fuel are usually associated with lower NOx emissions [8,9]. An increase in cetane number reduces the size of the premixed combustion by reducing the ignition delay. This results in lower NOx formation rates given that the combustion pressure rises more slowly, giving more time for cooling through heat transfer and dilution and leading to lower localized gas temperatures [8, 10].

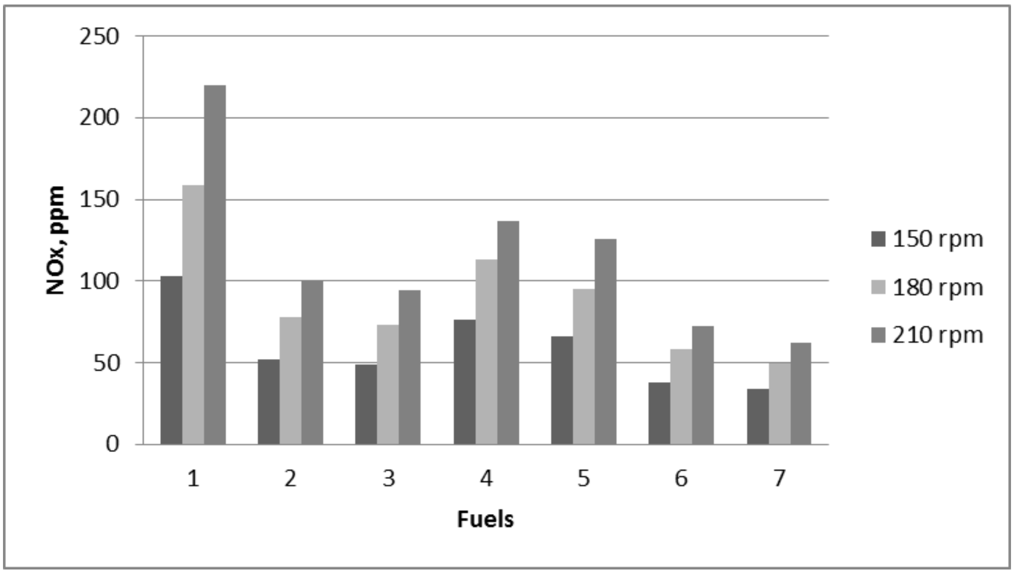

Fig. 2 Exhaust emission of NOx for different fuels and engine speeds, ppm

Furthermore, aromatic and poly-aromatic hydrocarbons are responsible for higher NOx emissions [8, 11, 12, 13]. This is probably due to the higher flame temperatures associated with aromatic compounds. By reducing the aromatics, the flame temperature drops, which leads to a lower NOx production rate. As a result, the addition of biodiesel which does not contain the above classes of compounds reduces the NOx emissions from the engines. The aromatics have high carbon–hydrogen ratios and consequently fuels with lower aromatics will lead to a smaller amount of CO_2 and larger amount of H_2O being formed in comparison to highly aromatic fuels. Since H_2O has a lower tendency to dissociate at high temperatures (compared to CO_2), this leads to low aromatic fuels having lower concentrations of $O^{\bullet}$ radicals, which further reduces the kinetic production of NO [8]. The same trend was also reported by [8, 14, 15]. Others reported an increase of NOx emission with an increase in biodiesel proportion in blended fuels mostly due to increased oxygen content of biodiesel fuels [16, 17].

Comparing biodiesel feedstock type, blends containing biodiesel made of waste frying oils showed somewhat higher NOx emission than blends containing biodiesel made from olive husk oil, which could be due to their higher poly-aromatic and total aromatics content.

3.2.2 Sulfur Dioxide, SO_2

The exhaust emission of SO_2 is strongly dependent on fuel sulfur content. Given that biodiesel has no sulfur content, the blending of diesel fuel with biodiesel can reduce its sulfur content and thus decrease the emission of SO_2. Diesel fuel used in this experiment was standard fuel used for yachts and vessels sailing in territorial waters of Montenegro with sulfur content below 10 ppm (Table 2).

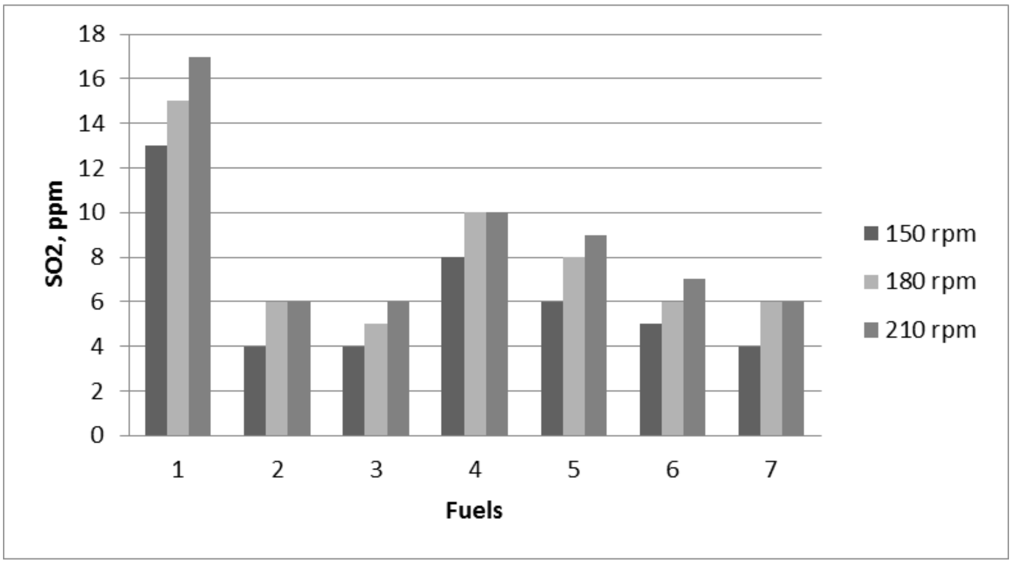

Fig. 3 Exhaust emission of SO_2 for different fuels and engine speeds, ppm (to be placed in section 3.2.2)

Figure 3 reveals that SO_2 emission increased with an increase in engine speed. The reason for this increase is that the more fuel is consumed the more sulfur in fuel is combusted.

Furthermore, the emission of SO_2 from biodiesel-fueled engine was lower from 33 % (in case of diesel fuel blended with biodiesel made of waste frying palm oil) to 70 % (in case of diesel fuel blended with biodiesel made of waste frying sunflower oil) compared to diesel-fueled engine.

Sulfur in diesel fuel helps lubricate the moving parts of the engine. Hence, the reduction of the fuel sulfur content in fuels decreases its lubricity [18]. Addition of as little as 2% of biodiesel into marine diesel fuel significantly improves the lubricity of the moving parts of a marine engine [19]. Therefore, adding biofuels in diesel fuel lowers SO_2 emission and improves fuel lubricity, with the latter being very important for older two-stroke slow-speed engines, such as the engine used in this experiment.

3.2.3 Carbon Monoxide, CO

CO emissions are controlled primarily by the air / fuel ratio. For fuel rich mixtures, CO concentration in the exhaust increases with decreasing the air / fuel ratio, as the amount of fuel increases. For fuel lean mixtures, CO concentration in the exhaust varies little with the air / fuel ratio. Diesel engines always operate well on the leaner side of stoichiometric [20].

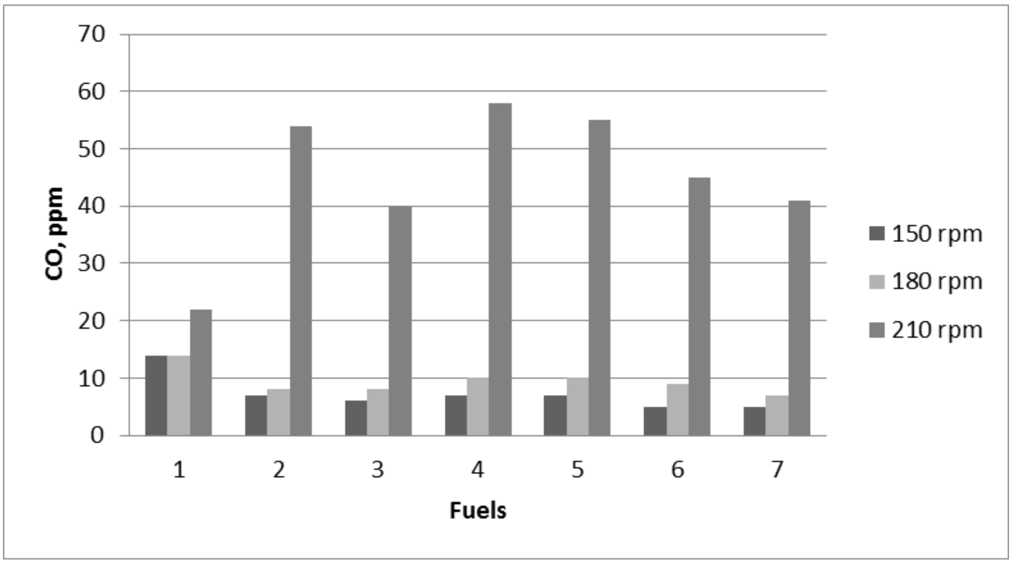

Fig. 4 Exhaust emission of CO for different fuels and engine speeds, ppm

CO emission slightly increased with an increase in engine speeds from 150 rpm to 180 rpm, whereas it increased significantly with an increase in engine speeds from 180 rpm to 210 rpm, as shown in Figure 4. The reason for the latter is that the air / fuel ratio significantly decreases with the increase of engine speed. Similar trends were reported by [16, 21, 22].

Furthermore, emission of CO from biodiesel blends fueled engine was lower in the range from 28 % (in case of diesel fuel blended with biodiesel made of waste frying palm oil) to 64 % (in case of diesel fuel blended with biodiesel made of olive husk oil) compared to diesel-fueled engine at low and medium engine speeds. This could be possible because of the oxygenated nature of biodiesel fuel. When biodiesel blends are utilized, owing to the inbuilt oxygen in the fuel, the local air / fuel ratio during the combustion becomes leaner, which results in the reduction in the CO from biodiesel blends. This trend was also reported by [16, 23]. However, when applying maximum engine speed there is an evident increase in CO emitted when using biodiesel blends, with an increase of up to 62 % compared to the CO emitted when using diesel fuel. At this highest engine speed, with local air / fuel ratios becoming richer, poor combustion and other biodiesel properties minimize the influence of its higher oxygen content. The same trend was also reported by [24, 25].

Comparing biodiesel feedstock type, blends containing biodiesel made of waste frying palm oil showed somewhat higher CO emission than other biodiesel blends, regardless of the engine speed. This could be due to its higher carbon content.

4. Conclusion

In the present study, an influence of the second-generation biodiesel (FAME) on the characteristics of exhaust emissions from marine diesel engine was investigated. A reversible two-stroke, low speed, cross-flow scavenging, four-cylinder marine diesel engine was used. The engine was fueled with pure diesel fuel and blends containing 7% and 20% of three types of biodiesel, made of waste frying sunflower oil, waste frying palm oil and olive husk oil. The experimental results may lead to the following conclusions:

- There is a trend of NOx emission reduction when using biodiesel blends, which could be attributed to their higher cetane number and lower aromatic content.
- There is a trend of SO_2 emission reduction when using biodiesel blends, which could

be attributed to their lower sulfur content.

- There is a trend of CO emission reduction when using biodiesel blends, which could be attributed to their oxygenated nature making leaner combustion.
- When blended with diesel fuel, biodiesel made of olive husk oil showed better gaseous emission performances than biodiesel made from waste frying palm oil and waste frying sunflower oil, which could be attributed to its lower poly-aromatic and total aromatics content, as well as its lower carbon content.

ACKNOWLEDGMENTS

The authors would like to thank the Montenegrin Ministry of Science for financial support under a national grant.

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Submitted: 16.06.2016
Accepted: 14.09.2016.

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Vilsonovo setaliste 9, Sarajevo, Bosnia and Herzegovina

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Adresa: Ruđera Boškovića 37, 21000, Split, Hrvatska (Službena)

O MENI

Rad u nastavi na svim razinama, mentoriranje doktoranada, znanstveno istraživanje osnovano na numeričkim i eksperimentalnim analizama procesa u motorima s unutarnjim izgaranjem kao i ostalih elemenata brodskih energetskih sustava - posebno s aspekta emisija ispušnih plinova i energetske učinkovitosti.

RADNO ISKUSTVO

01/10/2021 – TRENUTAČNO Split, Hrvatska

REDOVITI PROFESOR U TRAJNOM IZBORU, ZNANSTVENI SAVJETNIK U TRAJNOM IZBORU

SVEUČILIŠTE U SPLITU - POMORSKI FAKULTET

Predstojnik zavoda za brodostrojarstvo/Ravnatelj centra za praktičnu nastavu/Redovni profesor u trajnom izboru iz područja tehničkih znanosti/ Znanstveni savjetnik u trajnom zvanju
https://www.pfst.unist.hr/hr/o-fakultetu-hr/ustroj/zavodi-i-katedre; https://www.pfst.unist.hr/hr/o-fakultetu-hr/ustroj/tijela-fakulteta
■ Redoviti profesor/znanstveni savjetnik u trajnom izboru u znanstvenom području tehničkih znanosti, polju strojarstva, grani brodsko strojarstvo
■ Nastavnik na kolegijima : Preddiplomski studij: Brodski motori, Brodski energetski sustavi, Brodski generatori pare i toplinske turbine.
■ Nastavnik na doktorskom studiju: Modeliranje i simuliranje procesa motora SUI.

01/10/2018 – 01/06/2019 Split, Hrvatska

PRODEKAN ZA POSLOVODSTVO/REDOVNI PROFESOR IZ PODRUČJA TEHNIČKIH ZNANOSTI

SVEUČILIŠTE U SPLITU - POMORSKI FAKULTET

■ Član uprave Fakulteta, prodekan za poslovodstvo.
■ Povjerenik za studentska pitanja.
■ Član nakladničkog savjeta sveučilišnih novina "Universitas".
■ Redoviti profesor u znanstvenom području tehničkih znanosti, polju strojarstva, grani brodsko strojarstvo
■ Nastavnik na kolegijima : Preddiplomski studij: Brodski motori, Brodski energetski sustavi, Brodski generatori pare
i toplinske turbine, diplomski studij: Energetski sustavi u pomorstvu, Brodski prekrcajni sustavi.
■ Nastavnik na doktorskom studiju: Modeliranje i simuliranje procesa motora SUI.

01/11/2014 – 01/10/2018 Split, Hrvatska

DEKAN/IZVANREDNI PROFESOR IZ PODRUČJA TEHNIČKIH ZNANOSTI SVEUČILIŠTE U SPLITU - POMORSKI FAKULTET

■ Čelnik fakulteta, član Senata Sveučilišta u Splitu.
■ Predsjednik Upravnog vijeća Studentskog centra, član Upravnog vijeća Studentskog centra.
■ Član nakladničkog savjeta sveučilišnih novina "Universitas".
■ Izvanredni profesor u znanstvenom području tehničkih znanosti, polju strojarstva, grani brodsko strojarstvo
■ Nastavnik na kolegijima : Preddiplomski studij: Brodski motori, Brodski energetski sustavi, Brodski generatori pare i toplinske turbine, diplomski studij: Energetski sustavi u pomorstvu, Brodski prekrcajni sustavi.
■ Nastavnik na doktorskom studiju: Modeliranje i simuliranje procesa motora SUI.

2010 – 2014 Split, Hrvatska
PRODEKAN ZA POSLOVODSTVO/DOCENT IZ PODRUČJA TEHNIČKIH ZNANOSTI SVEUČILIŠTE U SPLITU - POMORSKI FAKULTET

■ Član uprave fakulteta, prodekan za poslovodstvo.
■ Sudjelovanje u Savjetu Ministarstva mora - Uprava za pomorstvo, za donošenje izmjena pravilnika vezano za uvođenje Posebnog programa obrazovanja za stjecanje časničkih zvanja NN. 142/10.
■ Član je izdavačkog savjeta časopisa Brodogradnja.
■ Član je uređivačkog tima u međunarodnom znanstvenom časopisu „Transaction on Maritime Science"
■ Docent u znanstvenom području tehničkih znanosti, polju strojarstva, grani brodsko strojarstvo
■ Nastavnik na kolegijima : Preddiplomski studij: Brodski motori, Brodski energetski sustavi, Brodski generatori pare i toplinske turbine, diplomski studij: Energetski sustavi u pomorstvu.

2009 – 2010 Split, Hrvatska
VODITELJ STUDIJA BRODOSTROJARSTVA SVEUČILIŠTE U SPLITU - POMORSKI FAKULTET

■ Priprema i organizacija nastave na preddiplomskom / diplomskom studiju,
■ Priprema i izrada prijedloga studijskog programa i izvedbenog plana nastave u suradnji s nastavnicima odgovarajućeg studija,
■ Briga o osiguranju materijalnih i ostalih uvjeta za realizaciju studija.
■ Nastavnik na kolegijima : Brodski motori, Brodski energetski sustavi, Brodski generatori pare i toplinske turbine.

2008 – 2009 Split, Hrvatska
PREDSTOJNIK ZAVODA ZA POMORSKU TEHNOLOGIJU JAHTA I MARINA SVEUČILIŠTE U SPLITU - POMORSKI FAKULTET

■ Planiranje, ustrojavanje i koordiniranje znanstvenog, nastavnog i stručnog rada zavoda,
■ Briga o pokrivenosti nastave izabranim nastavnicima (u stalnom radnom odnosu i vanjskim suradnicima) i njihovom opterećenju u suradnji s prodekanom za nastavu.
■ Priprema i sazivanje sjednice zavoda.
■ Nastavnik na kolegijima : Sustavi jahti, Brodski motori, Brodski energetski sustavi, Brodski generatori pare i toplinske turbine.

1996 – 2005 Split, Hrvatska
VIŠI PREDAVAČ IZ PODRUČJA TEHNIČKIH ZNANOSTI SVEUČILIŠTE U SPLITU - POMORSKI FAKULTET

■ Voditelj izvanrednog studija za pomorce na Pomorskom fakultetu u Splitu (2001-2002).
■ Pomoćnik voditelja Centra za izobrazbu pomoraca na Pomorskom fakultetu u Splitu (2000.-2002).
■ Predavač iz predmeta Brodski strojni kompleks, područje tehničke znanosti, polje tehnologija prometa i transporta (2000).
■ Voditelj Centra za izobrazbu pomoraca na Pomorskom fakultetu u Splitu (1996.-1999.) - sa zadacima organiziranja uvođenja novih tečajeva za pomorce i organiziranja izvođenja postojećih.

1991 – 1996 Split, Hrvatska
ASISTENT SVEUČILIŠTE U SPLITU - POMORSKI FAKULTET

■ Asistent iz kolegija Termodinamika.

OBRAZOVANJE I OSPOSOBLJAVANJE

10/10/2008 Rijeka, Hrvatska
DOKTOR TEHNIČKIH ZNANOSTI, ZNANSTVENO POLJE STROJARSTVO, ZNANSTVENA GRANA BRODSKO STROJARSTVO Sveučilište u Rijeci, Tehnički fakultet

Adresa Vukovarska 58, 51000, Rijeka, Hrvatska

1992 – 1998 Rijeka, Hrvatska

MAGISTAR TEHNIČKIH ZNANOSTI, ZNANSTVENO POLJE STROJARSTVO, ZNANSTVENA GRANA BRODSKO STROJARSTVO Sveučilište u Rijeci, Tehnički fakultet

Adresa Vukovarska 58, 51000, Rijeka, Hrvatska

1986 – 1991 Split, Hrvatska

DIPLOMIRANI INŽENJER POMORSKOG PROMETA, BRODOSTROJARSKOG SMJERA Pomorski fakultet u Dubrovniku-studij u Splitu

Adresa Zrinsko-Frankopansaka 38, 21000, Split, Hrvatska

JEZIČNE VJEŠTINE

Materinski jezik/jezici: **HRVATSKI**

Drugi jezici:

	RAZUMIJEVANJE		GOVOR		PISANJE
	Slušanje	Čitanje	Govorna produkcija	Govorna interakcija	
ENGLESKI	C1	C1	C1	C1	C1
TALIJANSKI	B1	B1	B1	B1	B1

Razine: A1 i A2: temeljni korisnik; B1 i B2: samostalni korisnik; C1 i C2: iskusni korisnik

DIGITALNE VJEŠTINE

MS Office (Word Excel PowerPoint) | Internet | Komunikacijski programi (Skype Zoom TeamViewer) | Rad na raunalu | Microsoft Word | Dobro sluenje alatima za matematiko modeliranje i simuliranje (Mathematica MATLAB Simulink)

VOZAČKA DOZVOLA

Vozačka dozvola: B

PROJEKTI

2020 – TRENUTAČNO

MZOS-projekt

Suradnik na projektu - HrZZ; IP-2020-02-6249 „Povećanje učinkovitosti, smanjenja štetnih emisija i hibridizacija brodskog energetskog sustava“

2014 – 2018

MZOS-projekt

Suradnik na projektu - Greener Approach to Ship Design and Optimal Route Planning (GASDORP) Funding: Croatian Science Foundation (HRZZ-IP-2013-11-8722)

2002 – 2013

MZOS-projekti

Suradnik na istraživačkom projektu br. 0069009, financiranom od strane Ministarstva znanosti, obrazovanja i športa Republike Hrvatske, pod nazivom: Numeričke simulacije i optimizacija dizelskih motora.

2000 – 2002

MZOS-projekt

Suradnik na projektu - br. 355-05-12-01, financiranom od strane Ministarstva znanosti, obrazovanja i športa Republike Hrvatske, pod nazivom: *Primjena nautičkog simulatora u obrazovanju pomoraca – organizacijski i ergonomski činioci u funkciji optimalnog upravljanja brodom.*

2014 – 2017
Tempus projekt

Suradnik na projektu - TEMPUS “Modernizing and harmonizing maritime education in Montenegro and Albania” MArED
No. 544257-TEMPUS-1-2013-1-ME-TEMPUS-JPCR “Mared”.

2013 – 2015
Bilateralni projekt HRVATSKA - CRNA GORA

Suradnik na HRVATSKO-CRNOGORSKOM projektu znanstvene grane brodostrojarstvo: Mogućnost smanjenja emisije onečišćavanja sa brodova u crnogorskom i hrvatskom dijelu Jadrana implementacijom Marpol konvencije Aneksa VI.

VJEŠTINE UPRAVLJANJA I RUKOVOĐENJA

Zapovjednik jahte 500 BT

ORGANIZACIJSKE VJEŠTINE

Rukovoditeljske vještine

■ Bogato iskustvo u upravljanju i rukovođenju (dekan, predsjednik upravnog vijeća, prodekan za poslovodstvo, predstojnik zavoda, ravnatelj centra).
■ Izuzetne organizacijske sposobnosti usavršene tijekom uvođenja studija Vojnog pomorstva, organizacije nastave, vođenja studija, trening centra i centra za praktičnu nastavu te institucionalnog razvijanja suradnje s nastavnim bazama.
■ Rukovođenje poslovnim procesima i upravljanje financijama.
■ Izuzetno vladanje postupcima upravljanja kvalitetom.
■ Razvijanje ideje organiziranja posebnog programa obrazovanja (cjeloživotnog programa) studija za zaposlene pomorce, izrađivanje posebnog plana i programa izvođenja nastave, koji je prilagođen vremenskim mogućnostima zaposlenih pomoraca, a u skladu s programom odobrenim od Nacionalnog vijeća, te posebno usklađen s međunarodnom konvencijom (STCW).

KOMUNIKACIJSKE I MEĐULJUDSKE VJEŠTINE

Komunikacijske i međuljudske vještine

■ Izvrsne komunikacijske vještine stečene prilikom dugogodišnjeg rada u nastavnoj djelatnosti.
■ Izvrsne komunikacijske vještine stečene tijekom obnašanja funkcije dekana Pomorskog fakulteta, predsjednika upravnog vijeća SC, odnosno prodekana za poslovodstvo.

PUBLIKACIJE U ZADNJIH 5 GODINA

Fuel Exergy Based on the Chemical Equilibrium of Combustion Gases

P Jurić, G Radica, N Račić, Z Jurić
10th IMSC-International Maritime Science Conference, 2023, 59-68

Poveznica https://scholar.google.com/citations?view_op=view_citation&hl=hr&user=5Hv9m64AAAAJ&sortby=pubdate&citation_for_view=5Hv9m64AAAAJ:NhqRSupF_l8C

Energy Efficiency Analysis of Variable Frequency Driven Centrifugal Pump in Merchant Vessel Cooling System

G Rilje, N Račić, D Đorđe, M Katalinić
10th IMSC-International Maritime Science Conference, 2023, 91-103

Poveznica https://scholar.google.com/citations?view_op=view_citation&hl=hr&user=5Hv9m64AAAAJ&sortby=pubdate&citation_for_view=5Hv9m64AAAAJ:D03iK_w7-QYC

Maritime Alternative Fuels and Technologies for Sustainable future

G Radica, T Vidović, T Sumić, T Mrakovčić, N Račić, M Jelić, B Lalić, ...
10th IMSC-International Maritime Science Conference, 2023, 348-356

Poveznica https://scholar.google.com/citations?view_op=view_citation&hl=hr&user=5Hv9m64AAAAJ&sortby=pubdate&citation_for_view=5Hv9m64AAAAJ:a0OBvERweLwC

Determination of Benefits of the Application of CMMS Database Improvement Proposals

Stazić, Ladislav; Račić, Nikola; Stanivuk, Tatjana; Dobrota, Đorđe
Applied sciences (Basel), **13** (2023), 4; 2731, 13 doi:10.3390/app13042731 (međunarodna recenzija, članak, znanstveni)

Poveznica https://www.mdpi.com/2076-3417/13/4/2731

Exhaust emissions reduction and fuel consumption from the LNG energy system depending on the ship operating modes

Martinić-Cezar, Siniša; Bratić, Karlo; Jurić, Zdeslav; Račić, Nikola
Pomorstvo (Scientific Journal of Maritime Research), **36(2022)** (2022), 2; 338-346 doi:10.31217/p.36.2.17 (međunarodna recenzija, pregledni rad, znanstveni)

Poveznica https://www.pfri.uniri.hr/web/hr/dokumenti/pomorstvo/2022/12/17_678-Martinić-Cezar.et.al.pdf

Methodology for testing shaft slide bearings of the ship propulsion system

Vetma, Vladimir; Vulić, Nenad; Račić, Nikola
// Conference Proceedings "Mechanical Technologies and Structural Materials - MTSM 2022"/ Split: Croatian Society for Mechanical Technologies, **70** (2022), 161-168, 2022.

Poveznica https://www.bib.irb.hr/1223705

Technical and Ecological Aspects of Water-lubricated Stern Tube Bearings

V Pelić, T Mrakovčić, R Radonja, N Račić
Pomorski zbornik, 289-304, Rijeka 2022.

Poveznica https://scholar.google.com/citations?view_op=view_citation&hl=hr&user=5Hv9m64AAAAJ&sortby=pubdate&citation_for_view=5Hv9m64AAAAJ:YFjsv_pBGBYC

EXPERIMENTAL INVESTIGATION OF MARINE ENGINE EXHAUST EMISSIONS

L Mihanović, M Jelić, G Radica, N Račić
Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 1-14, 2021.

Poveznica https://scholar.google.com/citations?view_op=view_citation&hl=hr&user=5Hv9m64AAAAJ&sortby=pubdate&citation_for_view=5Hv9m64AAAAJ:hMod-77fHWUC

Developments in Marine Hybrid Propulsion

Jelić, Maro; Radica, Gojmir; Račić, Nikola; Mrzljak, Vedran
6th International Conference on Smart and Sustainable Technologies (SpliTech) 2021 - Proceedings
Split: IEEE, 2021. str. 1-6 doi:10.23919/SpliTech52315.2021.9566449

Analysis of two-stroke low speed marine engines operating on alternative fuels

Radica Gojmir, Mrakovčić Tomsilav, Račić Nikola, Jelić Maro, Lalić Branko, Pelić Vladimir, Bratić Karlo, Bulat Domagoj
9th global conference on global warming gcgw 2021- conference proceedings / Zagreb, Croatia, 2021. str. 279-282

EXHAUST EMISSIONS FROM MARINE 4-STROKE ENGINE ON THE THREE FUEL TYPES

Martinić, Siniša-Cezar; Bratić, Karlo; Slišković Merica; Račić Nikola
2ST INTERNATIONAL CONFERENCE OF MARITIME SCIENCE & TECHNOLOGY NAŠE MORE 2021 / Mišković, Dario (ur.).

Dubrovnik: University of Dubrovnik, Maritime Department, 2021. str. 227-241 doi:504.5:621.43.068

Marine engines running on hydrogen additive in diesel fuel for emission reduction

Radica, Gojmir; Mrakovčić, Tomislav; Račić, Nikola; Jelić, Maro; Lalić, Branko; Pelić, Vladimir; Bratić, Karlo; Kozina, Ante; Bulat, Domagoj
6th International Conference on Smart and Sustainable Technologies (SpliTech) 2021 - Proceedings
Split: IEEE, 2021. Bol-Brač

An alternative and hybrid propulsion for merchant ships: current state and perspective

Jelić, Maro; Mrzljak, Vedran; Radica, Gojmir; Račić, Nikola
Energy sources part A-recovery utilization and environmental effects, 43 (2021), 1963354, 33 doi: 10.1080/15567036.2021.1963354

Podizanje razine sigurnosti plovidbe upotrebom sustava daljinskog nadzora na objektima pomorske signalizacije

Ivan Karin; Nikola Račić; Ivan Torlak; Tomislav Peša
MIPRO 2021. Opatija, Hrvatska, 2021. str. 136-142

Air Pollutant Emission Measurement

Račić, Nikola; Lalić, Branko; Komar, Ivan; Vidović, Frane; Stazić, Ladislav
Pedagogika (Sofia), 2021 - 6S (2021), 132-140 doi:10.53656/ped21-6s.11air

Fault Tree Analysis as a replacement for manufacturers maintenance instructions

Stazić, Ladislav; Knežević, Vlatko; Račić, Nikola; Orović, Josip
2nd International Conference of Maritime Science & Technology Naše more 2021, Dubrovnik 2021. str. 325-331

Experimental investigation of exhaust emission from marine diesel engines

Mihanovic, Luka; Jelic, Maro; Sumic, Tino; Radica, Gojmir; Racic, Nikola
5th International Conference on Smart and Sustainable Technologies (SpliTech)
Split: IEEE, 2020. str. 1-5 doi:10.23919/splitech49282.2020.9243740

Modelling, performance improvement and emission reduction of large two-stroke diesel engine using multi-zone combustion model

Muše, Ante; Jurić, Zdeslav; Račić, Nikola; Radica, Gojmir
Journal of Thermal Analysis and Calorimetry, 141 (2020), 1; 337-350 doi:10.1007/s10973-020-09321-7

Modeling and optimization of slow speed two stroke marine Diesel engine using Multi zone combustion model

Muše, Ante; Radica, Gojmir; Račić, Nikola; Jurić, Zdeslav
4th International Conference on Smart and Sustainable Technologies (SpliTech)
Bol, Republika Hrvatska: IEEE, 2019. str. 1-5 doi:10.23919/splitech.2019.8782998

Piston ring material in a two-stroke engine which sustains wear due to catalyst fines

Vukičević, Miroslav; Račić, Nikola; Ivošević, Špiro
Brodogradnja, 70 (2019), 2; 155-169 doi:10.21278/brod70208

Cruise ship traffic in the Adriatic Sea: environmental impact

Perić, Tina; Račić, Nikola
8th International Maritime Science Conference (IMSC 2019) Budva, Crna Gora, 2019. str. 49-58

Model vrednovanja onečišćenja mora otpadnim vodama s brodova za kružna putovanja

Perić, Tina; Mihanović, Vice; Račić, Nikola

USAVRŠAVANJE

2008

Brodosplit, Tvornica dizel motora d.o.o.

Usavršavanje brodski motori MAN B&W, montaža i ispitivanje motora europass

Nikola Račić

Datum rođenja: 23/02/1968 | **Državljanstvo:** hrvatsko | **Spol:** Muško |

Telefonski broj: (+385) 21619404 (Službeni) | **E-adresa:** nikola.racic@pfst.hr |

WhatsApp Messenger: +385913701007 |

Adresa: Ruđera Boškovića 37, 21000, Split, Hrvatska (Službena)

O MENI

Rad u nastavi na svim razinama, mentoriranje doktoranada, znanstveno istraživanje osnovano na numeričkim i eksperimentalnim analizama procesa u motorima s unutarnjim izgaranjem kao i ostalih elemenata brodskih energetskih sustava - posebno s aspekta emisija ispušnih plinova i energetske učinkovitosti.

PUBLIKACIJE U ZADNJIH 5 GODINA

Fuel Exergy Based on the Chemical Equilibrium of Combustion Gases

P Jurić, G Radica, N Račić, Z Jurić
10th IMSC-International Maritime Science Conference, 2023, 59-68

Poveznica https://scholar.google.com/citations?view_op=view_citation&hl=hr&user=5Hv9m64AAAAJ&sortby=pubdate&citation_for_view=5Hv9m64AAAAJ:NhqRSupF_l8C

Energy Efficiency Analysis of Variable Frequency Driven Centrifugal Pump in Merchant Vessel Cooling System

G Rilje, N Račić, D Đorđe, M Katalinić
10th IMSC-International Maritime Science Conference, 2023, 91-103

Poveznica https://scholar.google.com/citations?view_op=view_citation&hl=hr&user=5Hv9m64AAAAJ&sortby=pubdate&citation_for_view=5Hv9m64AAAAJ:D03iK_w7-QYC

Maritime Alternative Fuels and Technologies for Sustainable future

G Radica, T Vidović, T Sumić, T Mrakovčić, N Račić, M Jelić, B Lalić, ...
10th IMSC-International Maritime Science Conference, 2023, 348-356

Poveznica https://scholar.google.com/citations?view_op=view_citation&hl=hr&user=5Hv9m64AAAAJ&sortby=pubdate&citation_for_view=5Hv9m64AAAAJ:a0OBvERweLwC

Determination of Benefits of the Application of CMMS Database Improvement Proposals

Stazić, Ladislav; Račić, Nikola; Stanivuk, Tatjana; Dobrota, Đorđe
Applied sciences (Basel), **13** (2023), 4; 2731, 13 doi:10.3390/app13042731 (međunarodna recenzija, članak, znanstveni)

Poveznica https://www.mdpi.com/2076-3417/13/4/2731

Exhaust emissions reduction and fuel consumption from the LNG energy system depending on the ship operating modes

Martinić-Cezar, Siniša; Bratić, Karlo; Jurić, Zdeslav; Račić, Nikola

Pomorstvo (Scientific Journal of Maritime Research), **36(2022)** (2022), 2; 338-346 doi:10.31217/p.36.2.17
(međunarodna recenzija, pregledni rad, znanstveni)

Poveznica https://www.pfri.uniri.hr/web/hr/dokumenti/pomorstvo/2022/12/17_678-Martinić-Cezar.et.al.pdf

Methodology for testing shaft slide bearings of the ship propulsion system

Vetma, Vladimir; Vulić, Nenad; Račić, Nikola
// Conference Proceedings "Mechanical Technologies and Structural Materials - MTSM 2022"/ Split: Croatian Society for Mechanical Technologies, **70** (2022), 161-168, 2022.

Poveznica https://www.bib.irb.hr/1223705

Technical and Ecological Aspects of Water-lubricated Stern Tube Bearings

V Pelić, T Mrakovčić, R Radonja, N Račić
Pomorski zbornik, 289-304, Rijeka 2022.

Poveznica https://scholar.google.com/citations?view_op=view_citation&hl=hr&user=5Hv9m64AAAAJ&sortby=pubdate&citation_for_view=5Hv9m64AAAAJ:YFjsv_pBGBYC

EXPERIMENTAL INVESTIGATION OF MARINE ENGINE EXHAUST EMISSIONS

L Mihanović, M Jelić, G Radica, N Račić
Energy Sources, Part A: Recovery, Utilization, and Environmental Effects, 1-14, 2021.

Poveznica https://scholar.google.com/citations?view_op=view_citation&hl=hr&user=5Hv9m64AAAAJ&sortby=pubdate&citation_for_view=5Hv9m64AAAAJ:hMod-77fHWUC

Developments in Marine Hybrid Propulsion

Jelić, Maro; Radica, Gojmir; Račić, Nikola; Mrzljak, Vedran
6th International Conference on Smart and Sustainable Technologies (SpliTech) 2021 - Proceedings
Split: IEEE, 2021. str. 1-6 doi:10.23919/SpliTech52315.2021.9566449

Analysis of two-stroke low speed marine engines operating on alternative fuels

Radica Gojmir, Mrakovčić Tomsilav, Račić Nikola, Jelić Maro, Lalić Branko, Pelić Vladimir, Bratić Karlo, Bulat Domagoj
9th global conference on global warming gcgw 2021- conference proceedings / Zagreb, Croatia, 2021. str. 279-282

EXHAUST EMISSIONS FROM MARINE 4-STROKE ENGINE ON THE THREE FUEL TYPES

Martinić, Siniša-Cezar; Bratić, Karlo; Slišković Merica; Račić Nikola
2ST INTERNATIONAL CONFERENCE OF MARITIME SCIENCE & TECHNOLOGY NAŠE MORE 2021 / Mišković, Dario (ur.).
Dubrovnik: University of Dubrovnik, Maritime Department, 2021. str. 227-241 doi:504.5:621.43.068

Marine engines running on hydrogen additive in diesel fuel for emission reduction

Radica, Gojmir; Mrakovčić, Tomislav; Račić, Nikola; Jelić, Maro; Lalić, Branko; Pelić, Vladimir; Bratić, Karlo; Kozina, Ante; Bulat, Domagoj
6th International Conference on Smart and Sustainable Technologies (SpliTech) 2021 - Proceedings
Split: IEEE, 2021. Bol-Brač

An alternative and hybrid propulsion for merchant ships: current state and perspective

Jelić, Maro; Mrzljak, Vedran; Radica, Gojmir; Račić, Nikola
Energy sources part A-recovery utilization and environmental effects, 43 (2021), 1963354, 33 doi: 10.1080/15567036.2021.1963354

Podizanje razine sigurnosti plovidbe upotrebom sustava daljinskog nadzora na objektima pomorske signalizacije

Ivan Karin; Nikola Račić; Ivan Torlak; Tomislav Peša
MIPRO 2021. Opatija, Hrvatska, 2021. str. 136-142

Air Pollutant Emission Measurement

Račić, Nikola; Lalić, Branko; Komar, Ivan; Vidović, Frane; Stazić, Ladislav
Pedagogika (Sofia), 2021 - 6S (2021), 132-140 doi:10.53656/ped21-6s.11air

Fault Tree Analysis as a replacement for manufacturers maintenance instructions

Stazić, Ladislav; Knežević, Vlatko; Račić, Nikola; Orović, Josip
2nd International Conference of Maritime Science & Technology Naše more 2021, Dubrovnik 2021. str. 325-331

Experimental investigation of exhaust emission from marine diesel engines

Mihanovic, Luka; Jelic, Maro; Sumic, Tino; Radica, Gojmir; Racic, Nikola
5th International Conference on Smart and Sustainable Technologies (SpliTech)
Split: IEEE, 2020. str. 1-5 doi:10.23919/splitech49282.2020.9243740

Modelling, performance improvement and emission reduction of large two-stroke diesel engine using multi-zone combustion model

Muše, Ante; Jurić, Zdeslav; Račić, Nikola; Radica, Gojmir
Journal of Thermal Analysis and Calorimetry, 141 (2020), 1; 337-350 doi:10.1007/s10973-020-09321-7

Modeling and optimization of slow speed two stroke marine Diesel engine using Multi zone combustion model

Muše, Ante; Radica, Gojmir; Račić, Nikola; Jurić, Zdeslav
4th International Conference on Smart and Sustainable Technologies (SpliTech)
Bol, Republika Hrvatska: IEEE, 2019. str. 1-5 doi:10.23919/splitech.2019.8782998

Piston ring material in a two-stroke engine which sustains wear due to catalyst fines

Vukičević, Miroslav; Račić, Nikola; Ivošević, Špiro
Brodogradnja, 70 (2019), 2; 155-169 doi:10.21278/brod70208

Cruise ship traffic in the Adriatic Sea: environmental impact

Perić, Tina; Račić, Nikola
8th International Maritime Science Conference (IMSC 2019) Budva, Crna Gora, 2019. str. 49-58

Model vrednovanja onečišćenja mora otpadnim vodama s brodova za kružna putovanja

SVEUČILIŠTE U SPLITU
POMORSKI FAKULTET

UNIVERSITY OF SPLIT
FACULTY OF MARITIME STUDIES

KLASA: 029-06/23-06/0014
URBROJ: 2181-197-00-23-0003
Split, 3. studenoga 2023. godine

Na temelju članka 43. Zakona o visokom obrazovanju i znanstvenoj djelatnosti ("Narodne novine", broj 119/2022) te članka 48. i članka 60. Statuta Pomorskog fakulteta, Fakultetsko vijeće je, na 14. elektroničkoj sjednici održanoj 3. studenoga 2023. godine donijelo

ODLUKU

o izboru prof. dr. sc. Nikole Račića na više radno mjesto redoviti profesor u trajnom izboru u znanstvenom području tehničkih znanosti, polju strojarstvo, grana brodsko strojarstvo na Zavodu za brodostrojarstvo

Obrazloženje:

Utvrđuje se da je na 12. sjednici održanoj 4. listopada 2023. godine Fakultetsko vijeće donijelo Odluku o pokretanju postupka izbora dr. sc. Nikole Račića na više radno mjesto redoviti profesor u trajnom izboru u znanstvenom području tehničkih znanosti, polju strojarstvo, grana brodsko strojarstvo na Zavodu za brodostrojarstvo. Na istoj sjednici su imenovani članovi Stručnog Povjerenstva za davanje ocjene o ispunjavanju zakonskih kriterija za izbor u sljedećem sastavu:

- prof. dr. sc. Nenad Vulić, predsjednik
- prof. dr. sc. Gojmir Radica, član, Sveučilište u Splitu FESB
- prof. dr. sc. Maro Jelić, član Sveučilište u Dubrovniku, Pomorski odjel

Fakultetsko vijeće je usvojilo obrazloženo mišljenje Stručnog povjerenstva za davanje ocjene o ispunjavanju zakonskih kriterija za izbor, da prof. dr. sc. Nikola Račić ispunjava kriterije za izbor na više radno mjesto redovitog profesora u trajnom izboru te je temeljem toga donijelo Odluku o ispunjavanju kriterija za izbor prof. dr. sc. Nikole Račića na više radno mjesto redoviti profesor u trajnom izboru u znanstvenom području tehničkih znanosti, polju strojarstvo, grana brodsko strojarstvo, kao u izreci.
Matični odbor za područje tehničkih znanosti - polja strojarstva, brodogradnje, tehnologije prometa i transport, zrakoplovstva, raketne i svemirske tehnike donio je 4. srpnja 2018. godine Odluku o izboru dr. sc. Nikole Račića u znanstveno zvanje višeg znanstvenog savjetnika u trajnom zvanju u znanstvenom području tehničkih znanosti, polje strojarstvo.
Sljedeći Uputu o primjeni odredbi Zakona o visokom obrazovanju i znanstvenoj djelatnosti koje se odnose na postupak izbora i reizbora na znanstveno-nastavna radna mjesta dobivenu od Ministarstva znanosti i obrazovanja, KLASA: 640-03/22-03/00013, URBROJ: 533-04-22-0001 Odluka Fakultetskog vijeća neće se prosljeđivati Matičnom odboru.
S prof. dr. sc. u trajnom izboru Nikolom Račićem, sklopit će se aneks ugovora o radu.
Ovu Odluku Fakultet dostavlja Sveučilištu u Splitu u skladu s člankom 23. st. 18. Statuta Sveučilišta u Splitu.

Dekan

prof. dr. sc. Pero Vidan

Dostaviti:

- Sveučilištu u Splitu
- prof. dr. sc. Nikoli Račiću
- Članovima Povjerenstva
- Službi za kadrovske i opće poslove
- Arhivi

Matični odbor za područje tehničkih znanosti
- polja strojarstva, brodogradnje, tehnologije prometa i transporta, zrakoplovstva, raketne i svemirske tehnike

KLASA: UP/I-640-03/18-01/0795
URBROJ: 355-06-04-18-0002
Zagreb, 4. srpnja 2018.

Na temelju članka 33. i 35. Zakona o znanstvenoj djelatnosti i visokom obrazovanju (NN 123/03, 198/03, 105/04, 174/04, 46/07, 45/09, 63/11, 94/13, 139/13, 101/14 i 60/15) Matični odbor za područje tehničkih znanosti – polja strojarstva, brodogradnje, tehnologije prometa i transporta, zrakoplovstva, raketne i svemirske tehnike, na 5. sjednici održanoj 4. srpnja 2018. donosi

ODLUKU
o izboru u znanstveno zvanje

Dr. sc. NIKOLA RAČIĆ, izvanredni profesor Pomorskog fakulteta Sveučilišta u Splitu, izabire se u znanstveno zvanje znanstvenog savjetnika u trajnom zvanju u znanstvenom području tehničkih znanosti – polje strojarstvo.

Obrazloženje

Sukladno članku 33. i 35. Zakona o znanstvenoj djelatnosti i visokom obrazovanju pristupnik dr. sc. Nikola Račić, podnio je dana 19. ožujka 2018. Tehničkom fakultetu Sveučilišta u Rijeci zahtjev za izbor u znanstveno zvanje znanstvenog savjetnika u trajnom zvanju, u znanstvenom polju strojarstvo.

Na prijedlog Stručnog povjerenstva imenovanog na sjednici Fakultetskog vijeća Tehničkog fakulteta Sveučilišta u Rijeci, dana 27. travnja 2018., koje je za pristupnika dalo svoje mišljenje o ispunjenju uvjeta iz čl. 15. i čl. 43. Pravilnika o uvjetima za izbor u znanstvena zvanja (NN 28/17), Fakultetsko vijeće Tehničkog fakulteta Sveučilišta u Rijeci na svojoj sjednici održanoj 29. lipnja 2018. utvrdilo je da pristupnik ispunjava sve uvjete za izbor u znanstveno zvanje znanstvenog savjetnika u trajnom zvanju u znanstvenom području tehničkih znanosti – polje strojarstvo.

Matični odbor prihvatio je prijedlog Fakultetskog vijeća Tehničkog fakulteta Sveučilišta u Rijeci te na 5. sjednici održanoj 4. srpnja 2018. izabrao pristupnika u znanstveno zvanje znanstvenog savjetnika u trajnom zvanju.

UPUTA O PRAVNOM LIJEKU: Protiv Odluke o izboru u znanstveno zvanje pristupnik nema pravo žalbe, ali može pokrenuti upravni spor pred Upravnim sudom u Rijeci u roku od 30 dana od dana dostave pristupniku. Tužba se predaje Upravnom sudu u Rijeci neposredno u pisanom obliku, usmeno na zapisnik ili se šalje poštom odnosno dostavlja elektronički.

Predsjednik Matičnog odbora

Prof. emeritus Mladen Franz

Odluka se dostavlja:
1. Dr. sc. Nikola Račić
2. Tehnički fakultet u Rijeci
3. Ministarstvo znanosti i obrazovanja

Curriculum Vitae

First name(s) / Surname(s)	**Danilo Nikolic**
Address(es)	(Business) Put I Bokeljske brigade 44, Dobrota, 85330 Kotor, Montenegro (Home) Džordža Vašingtona 92, Podgorica, Montenegro
Telephone(s)	+382 (0) 32 303184 Mobile: +382 (0) 67 615 512
Fax(es)	+382 (0) 32 303184
E-mail	danilo.nikolic@ucg.ac.me, dannikol@t-com.me
Nationality	Montenegrin
Date of birth	08-05-1969
Gender	Male
Employment / Occupational field	Full professor at the University of Montenegro Internal combustion engines, Fossil and alternative fuels, Fuel combustion and exhaust emission, Environmental protection and sustainable development in maritime transport

Work experience

Occupation or position held	**University of Montenegro** **Management:** • Rector of the University of Montenegro (2017 - 2021) • Dean of the Faculty of maritime studies in Kotor (2011 – 2017) • Founder and coordinator of the Centre for research, innovations and entrepreneurship @ Faculty of maritime studies (2016 –) **Academic advances:** • Full professor (2017 -) • Associate professor (2009 – 2017) • Assistant professor (2003 – 2009) • Teaching assistant (1995 – 2003)
Main activities and responsibilities	Lecturing, research, faculty/university management
Name and address of employer	University of Montenegro, Cetinjska 2, 810000 Podgorica, Montenegro
Type of business or sector	Higher education / Public
Dates	From October 1995 – up to now
Occupation or position held	**Member of the Scientific Committee for Transport of HAZU - Croatian Academy of Sciences and Arts**
Main activities and responsibilities	Transportation research
Name and address of employer	Croatian Academy of Sciences and Arts
Type of business or sector	Public
Dates	2019 – up to now
Occupation or position held	**Member of Montenegrin Council for higher education**
Main activities and responsibilities	Implementation of Montenegrin law on higher education in Montenegro
Name and address of employer	Ministry for education of Montenegro
Type of business or sector	Public
Dates	2015 – 2017
Occupation or position held	**President of the committee for oil and gas**
Main activities and responsibilities	Introduction of standards EN and ISO

Name and address of employer	Montenegrin Institute for standardisation
Type of business or sector	Public
Dates	2010 – up to now
Occupation or position held	**Committee member for energy efficiency and environmental protection**
Main activities and responsibilities	Project activities
Name and address of employer	Montenegrin Chamber of Commerce
Type of business or sector	Public
Dates	2009 – 2013
Occupation or position held	**Council President of Montenegrin Environmental Protection Agency**
Main activities and responsibilities	Activities related to governing of Montenegrin EPA
Name and address of employer	Montenegrin EPA - Environmental Protection Agency, Podgorica, Montenegro
Type of business or sector	Public agency
Dates	2008 - 2012

Education

Title of qualification awarded	**Visiting professor / researcher**
Principal subjects/occupational skills covered	Diesel engine, alternative fuels and exhaust emission
Name and type of organisation providing education and training	University of Michigan, Dept. of Mechanical eng., W.E. Lay automotive laboratory, Ann Arbor, MI, USA
Dates	2007/2008
Title of qualification awarded	**Visiting researcher**
Principal subjects/occupational skills covered	Alternative fuels and exhaust emission
Name and type of organisation providing education and training	Japanese National Institute of Advanced Industrial Science & Technology, Clean Power System Group, Tsukuba, Ibaraki, Japan
Dates	2005/2006
Title of qualification awarded	**PhD title obtained**
Principal subjects/occupational skills covered	Diesel engine, fuels and exhaust emission
Name and type of organisation providing education and training	University of Montenegro, Faculty of mechanical engineering, Podgorica, Montenegro / KEIO University, Dept. of System Design, Tokyo, Japan
Dates	2002
Title of qualification awarded	**Visiting researcher**
Principal subjects/occupational skills covered	Diesel engine, fuels and exhaust emission
Name and type of organisation providing education and training	KEIO University, Dept. of System Design, Tokyo, Japan
Dates	2000/2001
Title of qualification awarded	**Master of sciences title obtained**
Principal subjects/occupational skills covered	Marine diesel engine, fuels and exhaust emission
Name and type of organisation providing education and training	University of Belgrade, Faculty of mechanical engineering, Belgrade, Serbia
Dates	1999

Title of qualification awarded	**Bachelor of science diploma obtained**
Principal subjects/occupational skills covered	Motor vehicles and exhaust emission
Name and type of organisation providing education and training	University of Montenegro, Faculty of mechanical engineering, Podgorica, Montenegro
Dates	1995

Trainings

Title of qualification awarded	**Certificate of Completion**
Principal subjects/occupational skills covered	Energy Transition through 2050 - Climate Science, Low Carbon Energy and Carbon Capture Strategies that Lead to Net-Zero
Name and type of organisation providing education and training	International Human Resources Development Corporation IHRDC www. https://ihrdc.com/about-ihrdc/
Dates	2022
Title of qualification awarded	**Certificate of Participation**
Principal subjects/occupational skills covered	Digital Sustainable Technologies in the Blue Economy
Name and type of organisation providing education and training	NTNU Norwegian University of Science and Technology
Dates	2022
Title of qualification awarded	**Certificate of Attendance**
Principal subjects/occupational skills covered	Regional training on Directive (EU) 2016/802 and other EU Maritime Environmental Legislation
Name and type of organisation providing education and training	EMSA European Maritime Safety Agency
Dates	2019
Title of qualification awarded	**Certificate of Completion**
Principal subjects/occupational skills covered	Energy Efficiency In Shipping
Name and type of organisation providing education and training	Lloyds Maritime Academy https://informaconnect.com/lloyds-maritime-academy/
Dates	2017
Title of qualification awarded	**Certificate of Completion**
Principal subjects/occupational skills covered	Overview of Offshore Systems
Name and type of organisation providing education and training	Petroskills https://www.petroskills.com/
Dates	2017
Title of qualification awarded	**Certificate of Completion**
Principal subjects/occupational skills covered	Marine Pollution Prevention & Management
Name and type of organisation providing education and training	Lloyds Maritime Academy https://informaconnect.com/lloyds-maritime-academy/
Dates	2016
Title of qualification awarded	**Diploma**

Principal subjects/occupational skills covered	LNG fuelled ships - BASIC
Name and type of organisation providing education and training	NTNU Norwegian University of Science and Technology
Dates	2016
Title of qualification awarded	**Certificate of Training**
Principal subjects/occupational skills covered	Rolls-Royce Marine Acon LNG Familiarisation course
Name and type of organisation providing education and training	Rolls-Royce (Norway)
Dates	2014

Personal skills and competences

Mother language (s)	**Montenegrin**
Other language (s)	**English**

Self-assessment	**Understanding**		**Speaking**		**Writing**
European level (*)	Listening	Reading	Spoken interaction	Spoken production	
English	C1 Proficient user	C1 Proficient user	C1 Proficient user	C1 Proficient user	C1 Proficient user

(*) Common European Framework of Reference for Languages

Social skills and competences	Good to communicate with people with diverse background, internationally, based on many years of living abroad - USA (3 years) and Japan (1 years).
Organisational skills and competences	Proficient leadership skills (Rector of the University of Montenegro, Dean of Faculty for maritime studies Kotor, Council president at Montenegrin EPA, Executive director at different companies) and team work (different research activities)

Additional information

Grants and awards

- Fulbright fellowship at the University of Michigan in Ann Arbor, Dept. of Mechanical eng., W.E. Lay Automotive lab., USA, 2007-2008
- Fellowship from Japanese National Institute of Advanced Industrial Science & Technology - AIST, Clean fuels laboratory, Tsukuba Science city, Japan, 2005-2006.
- Fellowship from KEIO University, Iida Laboratory, Tokyo, Japan, 2000-2001

Memberships in international organizations

- A member of SAE – Society of Automotive Engineers (USA)

Community service

- A member of the Commission for driver´s license examination in Montenegro for all driving categories in front of Ministry for education. 1995 - 2000

Annexes	List of publications, projects

Annex 1 – Selected projects

1. Green Corridors for Carbon-Neutral Cruise and Ferry Shipping in the ADRION Region – GREENROUTES. Interreg VI - B IPA Adriatic Ionian – IPA ADRION - Cooperation Programme 2021-2027 – 1st Call for proposals. Project consortium coordinator prof. dr Danilo Nikolic (2024 - 2027).
2. Joint approach to Blue circular Economy for Adriatic and Ionian Region – JOINABLE. Interreg VI - B IPA Adriatic Ionian – IPA ADRION - Cooperation Programme 2021-2027 – 1st Call for proposals. Coordinator for partner institution University of Montenegro prof. dr Danilo Nikolic (2024 - 2027).
3. Developing innovation network for uptake of solutions in robotics and sensors to improve monitoring and prevention of pollution of freshwater and sea ecosystems – ROBONETCBC. Interreg VI-A, IPA CBC Croatia - Bosnia and Herzegovina – Montenegro, Coordinator for partner institution University of Montenegro prof. dr Danilo Nikolic (2024 - 2027).
4. Innovative Systems to enhance Antifraud Customs Controls (ISACC +). Interreg IPA SA Capitalisation Small-Scale Call. Coordinator for partner institution University of Montenegro prof. dr Danilo Nikolic (2024 - 2025).
5. Enhancing knowledge and skills at WB HEIs in preparation for zero carbon maritime transport and logistics society, Call: ERASMUS-EDU-2023-CBHE. Coordinator for partner institution University of Montenegro prof. dr Danilo Nikolic (15/01/2023 - 14/01/2026).
6. Development of Regional Joint Master Program in Maritime Environmental Protection and Management / MEP&M, Erasmus + CBHE Call for proposal 2020 EAC/A03/2019. Project consortium coordinator prof. dr Danilo Nikolic (15/01/2021 - 14/01/2024).
7. Sea Waste from Adriatic to Enhance Marine Composites, A bilateral cooperation research project between Italy and Montenegro, School of Science and Technology - University of Camerino and Faculty of maritime studies Kotor – University of Montenegro, co-financed by the Italian and Montengrin Governments (1.1.2023-31.12.2024). Coordinator for partner institution University of Montenegro prof. dr Danilo Nikolic.
8. Smart and Green Ports – SG_Ports, Interreg IPA Cross-border Cooperation Italia-Albania-Montenegro (2022 – 2023). Coordinator for partner institution University of Montenegro prof. dr Danilo Nikolic.
9. Sustainable development of BLUE economies through higher education and innovation in Western Balkan Countries – BLUEWBC, Erasmus + CBHE Call for proposal 2019 EAC/A03/2018. Coordinator for partner institution University of Montenegro prof. dr Danilo Nikolic (15/01/2020 - 14/01/2023).
10. Partnership for the prOmotion of a maRiTime cross-border Strategy PORTS 4.0 - Interreg IPA Cross-border Cooperation Italia-Albania-Montenegro. Coordinator for partner institution University of Montenegro prof. dr Danilo Nikolic (2020 – 2021).
11. Reforming doctoral studies in Montenegro and Albania – MARDS, Erasmus + CBHE Call for proposal 2018 EAC/A03/2017. Member of project team for coordinating institution University of Montenegro prof. dr Danilo Nikolic (15/01/2020 - 14/01/2023).
12. Protection underwater heritage through its digitalization and valorization as a novel touristic offer – WRECKS4ALL, Interreg IPA Cross-border Cooperation Croatia-Bosnia and Herzegovina-Montenegro 2014-2020, 2nd Call for Proposals. Project consortium coordinator (2020 – 2022).
13. Fostering Internationalization at Montenegrin HEIs through Efficient Strategic Planning - IESP, Erasmus + CBHE Call for proposal 2019 EAC/A03/2018. Project consortium coordinator prof. dr Danilo Nikolic (15/11/2019 - 14/11/2021).
14. Partnership for the Observation and study of new Routes and Transnational Sea-highways – PORTS Interreg IPA Cross-border Cooperation Italia-Albania-Montenegro. Coordinator for partner institution University of Montenegro prof. dr Danilo Nikolic (2018 – 2020).
15. International certification of maritime education in Montenegro – EDUMAR. HERIC program. University of Montenegro, Maritime Faculty Kotor, project leader prof. dr Danilo Nikolic (14/04/2016 - 14/5/2017).
16. Montenegro Sustainable Maritime Competence Development Initiative, HERD Maritime 2010-2014, Higher education, research and development in the Western Balkans - maritime sector programme 2012-2014. Project partner UofM Maritime Faculty Kotor, project leader for partner institution prof. dr Danilo Nikolic, collaboration between University of Montenegro/Maritime faculty Kotor with Alesund University College, Norway (june 2013 – june 2016).
17. Modernizing and harmonizing maritime education in Montenegro and Albania – MarED, TEMPUS IV – 6th Call for proposals, project coordinator University of Montenegro/Maritime faculty Kotor, project leader prof. dr Danilo Nikolic (01/12/2013 - 30/11/2016).
18. Development of Sustainable Interrelations between Education, Research and Innovation at WBC Universities in Nanotechnologies and Advanced Materials where Innovation Means Business. TEMPUS IV – 6th Call for proposals. Project partner University of Montenegro/Maritime faculty Kotor, project leader for partner prof. dr Danilo Nikolic (01/12/2013 - 30/11/2016).
19. Possibilities for Production of Liquid Biofuels from Renewable Sources and Their Applications for Diesel Engine Propulsion on the Ships in Montenegro - BIOPOWER. National Project financed by the Ministry of Science: University of Montenegro, Maritime Faculty Kotor, project leader prof. dr Danilo Nikolic (2012 - 2016).
20. Possibilities of exhaust gas emission reduction from ships in Montenegrin and Croatian parts of Adriatic sea with implementation of Marpol Annex VI code. Project leader prof. dr Danilo Nikolic. Supported by Montenegrin Ministry

of Science (bilateral cooperation with Croatia); collaboration between University of Montenegro/Maritime faculty Kotor with Maritime faculty, University of Split, Croatia (2013-2015.g.)

21. Production of liquid biofuels from renewable sources and their use in diesel engines on merchant and navy ships in Montenegro. Project leader prof. dr Danilo Nikolic. National project supported by Montenegrin Ministry of Science, 2012-2015.
22. Exploring the possibility of production of biofuels from waste materials and its application in the internal combustion engines. Project leader prof. dr Danilo Nikolic. Supported by Montenegrin Ministry of Science (bilateral cooperation with Bosnia and Herzegovina); collaboration between Maritime faculty in Kotor with Mechanical faculty, University of Sarajevo, Bosnia and Herzegovina (2012-2014.g.)

Annex 2 – Selected papers/reviews published in journals

1. Carlo Santulli, Cristiano Fragassa, Ana Pavlovic and Danilo Nikolic, Use of Sea Waste to Enhance Sustainability in Composite Materials: A Review, J. Mar. Sci. Eng. 2023, 11(4), 855; https://doi.org/10.3390/jmse11040855
2. Nada Marstijepovic, Sead Cvrk, Radmila Gagic, Ivan Filipovic, Danilo Nikolic, Application of biodiesel derived from olive oil production wastes at marine diesel engine and evaluation of gasseous emission trends, Thermal Science 2023 Volume 27, Issue 3 Part B, Pages: 2195-2203, https://doi.org/10.2298/TSCI220707218M
3. Gagic, R.; Skuric, M.; Djukanovic, G.; Nikolic, D. Establishing Correlation between Cruise Ship Activities and Ambient PM Concentrations in the Kotor Bay Area Using a Low-Cost Sensor Network. Atmosphere 2022, 13, 1819. https://doi.org/10.3390/atmos13111819
4. Giulia Zanier, Francesco Giunto, Andrea Petronio, Federico Roman, Radmila Gagić, Danilo Nikolic, Kotor Bay Area Hydrodynamics and Pollutant Dispersion Simulations: A Tool for Contingency Plans. EbookTechnology and Science for the Ships of the Future, 2018. Pages 604 – 611, DOI 10.3233/978-1-61499-870-9-604
5. Nikolić Danilo, Gagić Radmila, Ivošević Špiro, Estimation of Air Pollution from ships in the Boka Kotorksa Bay (2016). The Boka Kotorska Bay Environment, part of the series The Handbook of Environmental Chemistry pp 1-12. ISBN 1867-979X. Springer.
6. Nikolić Danilo, Cvrk S., Marstijepović N., Gagic R., Filipovic I., Influence of Biodiesel Blends on Chracteristics of Gaseous Emissions From Two Stroke, Low Speed Marine Diesel Engines. Advances in Application of Industrial Biomaterials pp 49 - 63. Print ISBN 978-3-319-62766-3, online ISBN 978-3-319-62767-0. Springer.
7. Nikolić Danilo, Marstijepović N., Cvrk S., Gagic R., Filipovic I. (2016) Evaluation of pollutant emissions from two-stroke marine diesel engine fueled with biodiesel produced from various waste oils and diesel blends. Brodogradnja/Shipbuilding: Theory and Practice of Naval Architecture, Marine Engineering and Ocean Engineering, Vol.67 No.4 December 2016. (online), pp 81-90. ISSN 0007-215X, eISSN 1845-5859.
8. Aleksandar Nikolić, Danilo Nikolić, Emilija Nikolić, Vesna Vujačić ‘‘Urban Noise Modelling In Boka Kotorska Bay‘‘, Promet – Traffic&Transportation, Vol. 26, 2014, No. 2, 151-157, ISSN 0353-5321 print, ISSN 1848-4069 online
9. Branko Lalić, Ivan Komar, Danilo Nikolić, ‘‘Optimization of Ship Propulsion Diesel Engine to Fulfill the New Requirements for Exhaust Emissions‘‘, TOMS, Transactions On Maritime Science 31, April 2014 Vol.3.No1.ISSN 1848-3305.
10. Nikolić A., Nikolić Danilo, "Evolution of equivalent noise levels in tourist resort Donja Lastva", Mathematica Montisnigri Vol XXIV (p. 261-270), 2012.
11. Kastratović G., Nikolić Danilo, (2013), Control of pollutant emissions from marine diesel engines. Kvalitet i izvrsnost, Year II, No 3-4, 2013, pp 64-67, ISSN 2217 – 852X.
12. Ivošević, Š., Bauk, S., Nikolić Danilo, Structural degradation of the bulk–carriers caused by the corrosion, Journal of Technics Technologies Education Management, (ISSN: 1840-1503), Vol.8, No.1, 2/3 2013.
13. Nikolić Danilo, Vujadinović R., ‘‘Legislation Harmonization in Republic of Montenegro With Eu in the Area of Motor Fuels Quality‘‘, Kvalitet, Časopis za unapređivanje kvaliteta, broj 7-8 86-89), ISSN 0354-2408, Srbija, Septembar 2007.
14. Vujadinović R., Nikolić Danilo, Dobovišek Ž., ‘‘Alternative approach to the modelling of CO2 emission from passenger vehicles‘‘, FUELS and LUBRICANTS, Journal for Tribology, Lubrication, Application of Liquid and Gaseous Fuels and Combustion Engineering, Volume 46 (129-148), ISSN 0350-350, Croatia, May 2007.
15. Shiotani H., Goto S., Kinoshita K., Nikolić Danilo, "Characteristics of Aldehydes and VOCs Emission from Off-Road Engines" SAE (Society of Automotive Engineers) Journal of Fuels and Lubricants (719-725), ISSN 978-0-7680-1836-3, SAD, Mart 2007.
16. Nikolić Danilo, Iida Norimasa, ‘‘Effect of intake CO2 concentrations on fuel spray flame temperatures and soot formations‘‘ Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, Volume 221, Number 12/2007, (1567–1574), ISSN 0954-4070, Professional Engineering Publishing, V. Britanija, Decembar 2007.
17. Oguma M., Goto S., Tsujimura T., Nikolić Danilo, ‘‘Analysis of Particulate Matter (PM) Emitted from DME Powered Direct Injection Diesel Engine – Measurement of PM Size Distribution‘‘, JSAE (Japanese Society of Automotive Engineers) Review, Volume 28, No2 (181-186), ISSN 1349-4724, Japan, April 2007.

18. Nikolic Danilo, Vujadinovic R., Norimasa Iida, „Experimental study on effects of different EGR ratio on flame temperature and soot formation using diesel fuels with different T90 distillation temperatures“, Strojniški Vestnik (str 863-871), ISSN 0039-2480, Slovenija, Decembar 2006.
19. Vujadinovic R., Nikolic Danilo, Ž. Dobovišek, „Alternative approach to modelling of CO2 emission from motor vehicles«, Fuels ans Lubricants, Journal for Tribology, Lubrication, Application of Liquid and Gaseous Fuels and Combustion Engineering, Zagreb 2006. ISSN 0350-350X
20. Shinya Takahashi, Nikolic Danilo, Kazunari Wakimoto, Norimasa Iida, „Effects of Aromatics Contents and 90% Distillation Temperature of Diesel Fuels on Flame Temperature and Soot Formation“, Society of Automotive Engineers Transactions, Journal of Fuels and Lubricants, SAE, USA, 2003.

Last up-date: May, 2024.

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UNIVERZITET CRNE GORE
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17.07.2018
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Na osnovu člana 72 stav 2 Zakona o visokom obrazovanju („Službeni list Crne Gore“ br. 44/14, 47/15,40/16, 42/17) i člana 32 stav 1 tačka 9 Statuta Univerziteta Crne Gore, Senat Univerziteta Crne Gore na sjednici održanoj 05.jula 2017.godine, donio je

O D L U K U
O IZBORU U ZVANJE

Dr Danilo Nikolić bira se u akademsko zvanje **redovni profesor Univerziteta Crne Gore za oblast Motori i vozila na Pomorskom fakultetu,** na neodređeno vrijeme .

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Predsjednica
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Na osnovu člana 72 stav 2 Zakona o visokom obrazovanju („Službeni list Crne Gore“, br. 44/14, 47/15, 40/16, 42/17, 71/17, 55/18, 3/19, 17/19, 47/19, 72/19 i 74/20 i 104/21 i 86/22) i člana 32 stav 1 tačka 9 Statuta Univerziteta Crne Gore, Senat Univerziteta Crne Gore, na sjednici održanoj 8.12.2023. godine, donio je

O D L U K U
O IZBORU U ZVANJE

Dr MIROSLAV VUKIČEVIĆ bira se u akademsko zvanje **docent Univerziteta Crne Gore** za oblast **Brodomašinstvo na Pomorskom fakultetu Univerziteta Crne Gore,** na period od pet godina.

SENAT UNIVERZITETA CRNE GORE
PREDSJEDNIK

Prof. dr Vladimir Božović, rektor

PERSONAL INFORMATION

Miroslav Vukičević

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miroslav.v@ucg.ac.me; vukicevic.miroslav@gmail.com

Sex Male | Date of birth 16/09/1981 | Nationality Montenegrin

WORK EXPERIENCE

From 2016 up to now

Teaching Assistant

University of Montenegro, Faculty of Maritime Studies (Put I Bokeljske brigade 44, Kotor, 85330, Montenegro)

- Researcher in the following fields: Marine auxiliary sistem, Marine Biology, Ecological Engineering, Engineering Education
  Business or sector: High-education institution

From 2004 up to 2016 Marine engineer *MITSUI O.S.K. LINES*

From 2000 up to 2004 Sports trainer Handball club Kotor, Boka

EDUCATION AND TRAINING

2022

PhD

PhD

University of Montenegro, Faculty of Maritime Studies Kotor, Montenegro

- Methodology for reducing the impact of catalytic residues on the durability of piston rings in low speed marine engines

2016

Master of Sciences

MSc

University of Montenegro, Faculty of Maritime Studies Kotor, Montenegro

- The possibility of using simulation software in order to predict nitrogen oxide (NOx) emissions from MAN B&W marine engines

2004

Bachelor of Sciences

BSc

University of Montenegro, Faculty of Maritime Studies Kotor, Montenegro

- Marine engineering

2000 Valedictorian in High School - Naval High School Kotor

[24/09/2018] till [28/09/2018] Erasmus + teaching mobility at UNIVERSITY OF THE AEGEAN, Chios, Greece

[7/03/2020] till [14/03/2020] Erasmus + teaching mobility at Óbuda University, HU BUDAPES, Hungary

[27/09/2021] till [12/10/2021] Erasmus + teaching mobility at University of Dubrovnik, Croatia

PERSONAL SKILLS

Mother tongue(s) Montenegrin

Other language(s)

	UNDERSTANDING		SPEAKING		WRITING
	Listening	Reading	Spoken interaction	Spoken production	
English	C1	C1	C1	C1	
Italian	B1	B1	B1	B1	

Levels: A1/2: Basic user - B1/2: Independent user - C1/2 Proficient user
Common European Framework of Reference for Languages

Communication skills — Very good

Organisational / managerial skills — Good ability for teamwork; From February 2023 he was head of the Training Center for seafarers at the Faculty of Maritime Studies Kotor.

Computer skills — Microsoft Office and Internet applications (regular Internet user)

Driving licence — A, B category

ADDITIONAL INFORMATION

- Able to communicate concisely and accurately.
- Good organizational skills.
- Willingness to work hard.
- Attends a lot of conferences about marine engineering

Publications
Presentations
Projects
Conferences
Seminars
Honours and awards
Memberships
References

Projects:

- Zero C (*Erasmus + project) "Enhancing knowledge and skils at WB HEIs in preparation for zero carbon maritime transport and logistics society",1.11.2023 – 31.10.2026)
- COST Action: CA22122 - Rethinking the Blue Economy
- Razvoj regionalnog zajedničkog master programa za zaštitu i upravljanje morskom sredinom – MEP&M" (Erasmus+ CBHE projekat br. 619239-EPP-1-2020-1-ME-EPPKA2-CBHE-JP)
- Erasmus + project Sustainable development of BLUE economies through higher education and innovation in Western Balkan Countries, akronim – BLUEWBC, January 2020 – January 2023.
- Montenegro Sustainable Maritime Competence Development Initiative, HERD Maritime 2010-2014, Higher education, research and development in the Western Balkans - Maritime Sector Programme 2012-2014. Project partner UoM Maritime Faculty Kotor, Project Leader for partner Prof. Dr. Danilo Nikolić, collaboration between Maritime Faculty Kotor with Alesund University College, Norway (June 2013 – June 2015);
- Modernizing and harmonizing maritime education in Montenegro and Albania – MarED, TEMPUS IV – 6th Call for proposals, project coordinator UoM Maritime Faculty Kotor (01/12/2013 - 30/11/2016);

Seminars:

- **23. Generalna skupština konfederacije udruženja pomorskih kapetana zemalja EU, Kotor 4. Maj 2018**
- **Lloyd's Register training course: Leaders of the Future, 17 - 19 October 2023 Kotor, Montenegro**

Papers/reviews published in journals:

1. **M. Vukičević,** B. Drašković, P.Mustur, T. Šorović: "Enviromental benefits and energy efficiency arising from optimization of vessel's voyage" 12 International conference on social and technological developmenth STED, 15 -18 June 2023 In Trebinje, Bosnia and Herzegovina ISSN 2303-498X
2. I. Petrović, Š. Ivošević, **M. Vukičević** What is a Risk of Increased Traffic in Boka Bay? –

Journal of Maritime Sciences (JMS) Vol. 23, No. 2/2022; November 2022 DOI: https://doi.org/10.56080/jms221106

3. Zorica Đurović, Milica Vuković-Stamatović & **Miroslav Vukičević**: "How much and what kind of vocabulary do marine engineers need for adequate comprehension of ship instruction books and manuals?" :ISSN: 1576-4737 Círculo de Lingüística Aplicada a la Comunicación 88,123-133, https://dx.doi.org/10.5209/clac.78300
4. Zorica Đurović & **Miroslav Vukičević**: "Hybrid Twinning on Marine Engine Simulators" Journal of Maritime Sciences (JMS) Vol.23 No.1/2022, ISSN 2787-8880 DOI: https://doi.org/10.56080/jms220508
5. Bratić, K., Stazić, L., **Vukičević, M.** and Lalić, B. (2021) "Cruise Vessels Air Pollution Inventory for the Port of Kotor", Transactions on Maritime Science. Split, Croatia, 10(1), pp. 200–207. doi: 10.7225/toms. v10.n01.016.
6. Vukičević, M., Račić, N., Ivošević, Š.: Piston ring material in two-stroke enigne which sustains wear due to catalyst fines, ISSN 0007-215X eISSN 1845-5859, Brodogradnja Vol. 70, No.2, 2019 http://dx.doi.org/10.21278/brod70208
7. Ivošević Š., Rudolf R., Majerič P., Kovač D., **Vukičević M**., "Pregled baznih istraživanja mogućnosti primjene materijala sa oblikom u nautičkoj industriji" God.35 Broj 22, Kotor 2019, ISSN 0352-1052
8. **Vukičević M**., Račić N., Vukašinović D. "Tretman teškog goriva sa aspekta štetnog teškog brodskog goriva sa aspekta štetnog djelovanja katalitičkih nešistoća" God.35 Broj 22, Kotor 2019, ISSN 0352-1052

Papers published in proceedings of the conferences:

1. **Vukičević M.,** Drašković B., Vukašinović D. "Scavenging drain analysis (SDA) from two-stroke diesel engine – most useful analysis" 12 International conference on social and technological developmenth STED, 15 -18 June 2023 In Trebinje, Bosnia and Herzegovina ISSN 2637-3298

2. D. Vukašinović , **M. Vukičević** , I. Petrović , R. Gagić : "Passenger vessel control loss and oil spill in port of Kotor area", KIMC3 3rd Kotor International Maritime Conference, November 2023 ISBN 978-86-80031-67-5

3. D.Kovač, S.Cvrk, **M. Vukičević**: "The possibility of increasing the efficiency of ship propulsion with cycle gas turbines" , Energetika 2023 , Zlatibor 12-15.09.2023,Srbija

4. **Miroslav Vukičević**, Nikola Račić & Boris Hrnčić: "CAUSES OF WEAR ON PISTON RINGS AND CYLINDER LINERS - "ISHIKAWA DIAGRAM" 2nd Kotor International Maritime Conference (KIMC 2022), November 27-30, 2022 Kotor, Montenegro ISBN 978-86-7664-226-7

5. **Miroslav Vukičević**, Igor Petrović, Zorica Đurović & Lazar Dragović: "HOW TO IMPROVE MONTENEGRIN SEAFARER COMPETITIVENESS IN THE INTERNATIONAL MARKET" 2nd Kotor International Maritime Conference (KIMC 2022), November 27-30, 2022 Kotor, Montenegro ISBN 978-86-7664-226-7

6. Vera Kapetanović, Igor Stanovčić, **Miroslav Vukičević**, Igor Petrović & Tatjana Dlabač: "KEY PERFORMANCE INDICATORS OF THE QUALITY MANAGEMENT SYSTEM IN THE FUNCTION OF MONITORING THE EDUCATION AND TRAINING OF SEAMEN AT THE FACULTY OF MARITIME STUDIES KOTOR" 2nd Kotor International Maritime Conference (KIMC 2022), November 27-30, 2022 Kotor, Montenegro ISBN 978-86-7664-226-7

7. Nikola Jelić and Luka Mijušković "THE IMPORTANCE OF TRAINING FOR OFFICERS AND CREW SERVING ON SHIPS SUBJECT TO IGF CODE" Supervisor: Assoc. Prof. Tatijana Dlabač, ***Miroslav Vukičević***, MSc,2nd Kotor International Maritime Conference (KIMC 2022), November 27-30, 2022 Kotor, Montenegro ISBN 978-86-7664-226-7

8. Nemanja Tabaš, Ana Simeunović, Blagoje Mičeta& Vasilije Kovačević "PERFORMANCE OF THE ELECTRICITY PRODUCTION ON THE ENGINE ROOM SIMULATOR"

Supervisor: Assoc. Prof. Tatijana Dlabač, ***Miroslav Vukičević***, MSc,2nd Kotor International Maritime Conference (KIMC 2022), November 27-30, 2022 Kotor, Montenegro ISBN 978-86-7664-226-7

9. Igor Petrović, Špiro Ivošević & **Miroslav Vukičević**: "Does Increased Traffic Increase Risk in Boka Bay?" 1ST Kotor International Maritime Conference (KIMC 2021) 26-27 November 2021, Kotor, Montenegro

10. Zorica Đurović & **Miroslav Vukičević**: "Hybrid "Twinning" in Maritime Education" 1ST Kotor International Maritime Conference (KIMC 2021) 26-27 November 2021, Kotor, Montenegro

11. Tripo Moškov, Filip Petričević & **Miroslav Vukičević:** "The Benefits of Sailing Skills for Future Seafarers" 1ST Kotor International Maritime Conference (KIMC 2021) 26-27 November 2021, Kotor, Montenegro
12. **Miroslav Vukičević,** Zorica Đurović, Boris Hrnčić & Karlo Bratić: "Optimization of Fuel Purifier Operation for More Efficient Elimination of Small Abrasive Impurities" 1ST Kotor International Maritime Conference (KIMC 2021) 26-27 November 2021, Kotor, Montenegro

13. Š. Ivošević, P. Majerič, **M. Vukičević,** R. Rudolf: "A Study of the Possible Use of Materials With Shape Memory Effect in Shipbuilding" Journal of Maritime and Transportation Sciences, Vol. Special edition No. 3, 2020. Page 265-277. ISSN 0554-6397 Konferencijski članak (Conference paper)

14. **Vukičević, M,** Cvrk, S, Kovač, D, Lalić, B.;" M easurement of torsional vibration on Propeller Shafts Using Code Discs and Optical Forks" 8th International maritime science conference IMSC 2019, Budva,11-12 April 2019 ISSN 1847-1498 Page 345-351

15. **Vukičević, M,** Ivošević, Š, Rudolf, R, Majerič, P.; "An Analysis of the Influence of Abrasive Particles in Fuel on the Degree of Damage to Piston Rings" 8th International maritime science conference IMSC 2019, Budva,11-12 April 2019 ISSN 1847-1498 Page 301-315

16. Bogdanović M., **Vukičević M**.; "The enviromental impacts of the offshore oil and gas industry" 21st DKMT Conference on Environment and Health, 06-08 June 2019, Faculty of Technology Novi Sad, Serbia ISBN 978-86-6253-107-0 Page 60-68

17. **Vukičević M.,** Bogdanović M., Kovač D., Vujičić S.; „Prospective jobs for montenegrin seafarers in the epicontinental area of Montenegro "1st International conference of maritime science & technology Naše more 2019, Dubrovnik, 17 – 18th October 2019, ISBN 978-953-7153-52-6 Page 600-610

18. **Vukičević M.,** Račić N., Vukašinović D.; „ Ways of reducing the content of catalytic fines in marine heavy fuel oil "1st International conference of maritime science & technology Naše more 2019, Dubrovnik, 17 – 18th October 2019, ISBN 978-953-7153-52-6, Page 611-624

19. Š. Ivošević, P. Majerič, **M. Vukičević,** R. Rudolf: "A study of the possible using of materials with shape memory effect in nautics" Eighth conference on marine technoogy in memoriam of the academician Zlatko Winkler November 15 and 16, 2019, Faculty of Engineering University of Rijeka (ISSN 0554-6397 Print, ISSN 1848-9052 Online):
20. **Vukičević Miroslav,** Mraković Ivan, Ivošević Špiro: „Analysis of the influence of preventive maintenance of main engines on working parameters and emissions ", 5ta konferencija "Održavanje 2018" Zenica, 10-12 maj 2018., str. 247 - 254, ISSN 1986-583X

21. **Miroslav Vukičević**, Radmila Gagić, Danilo Nikolić: „Application of simulation software in estimation of NOx emissions from ship's main engine at different loads ", Internacionalna konferencija IMSC Split,2017 str. 531-543, ISSN 1847-1498

22. Gagić, R., **Vukičević, M.,** Nikolić, D: "Estimation of PM emissions from cruise ships in Kotor Bay" 6th International conference WeBIOPATR 2017, Belgrade, Serbia, 6.-8.

	septembar 2017.