Emission Characteristics of CI Engine Running with Biodiesel

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Agendas

- Introduction
- Experimental facilities and test procedures
- Experimental results
  - Effects of biodiesel sources on engine emission
  - Effects of biodiesel blend ratio on engine emission
- Conclusions

Introduction

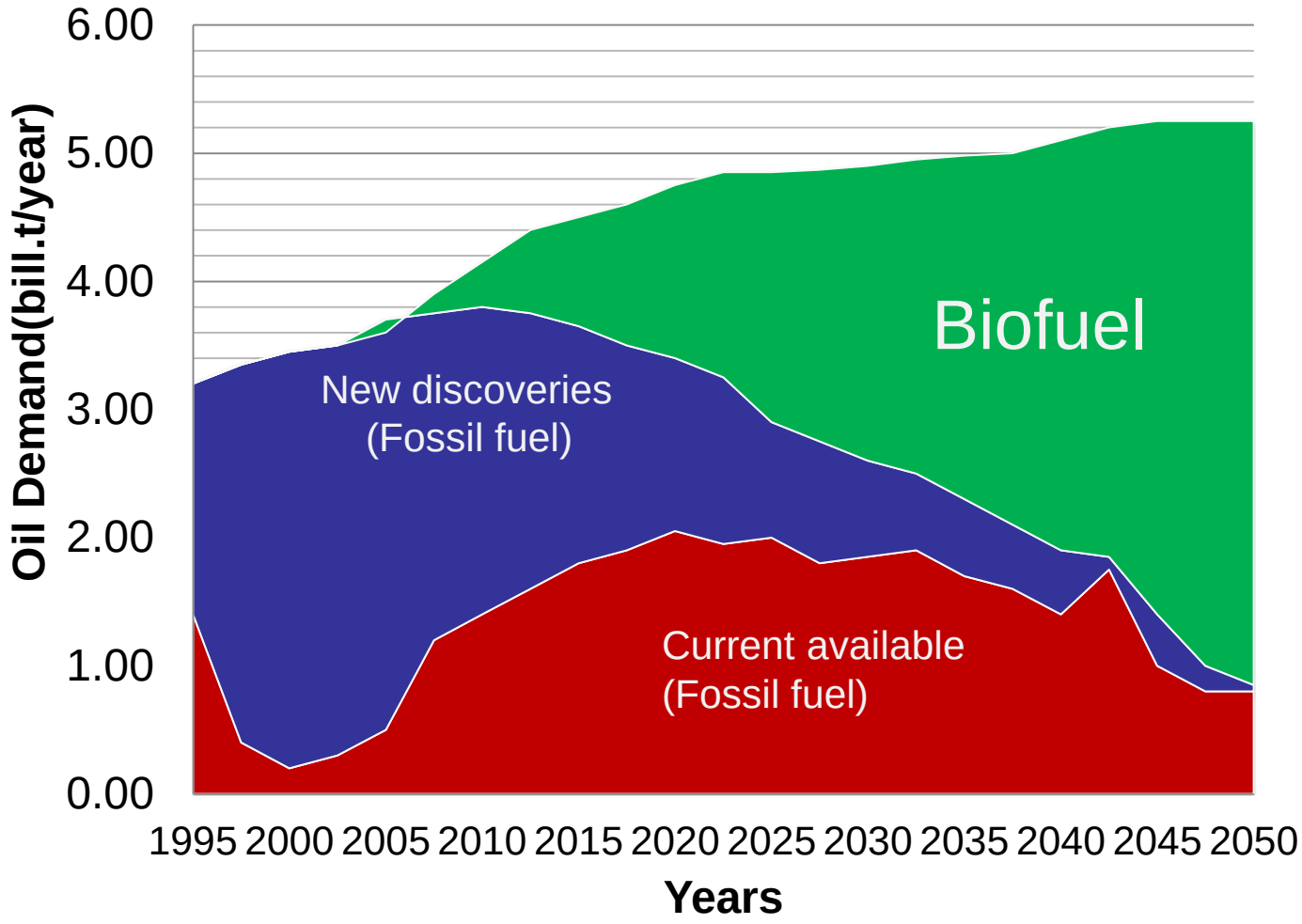
- On the past three decades, considerable efforts have been made to develop alternative fuels.
- Why do we need alternative fuels?

  ✓ Depletion of non-renewable oil reserves in the coming 30 - 50 years.

  ✓ Stringent emissions legislation for the transport sector (30% of emission caused by transport sector)

  ✓ Vulnerability of fossil fuel resource to political instability

Introduction (Cont.)



Oil Supply –Demand (Conemann, 1999)

Introduction (Cont.)

EU emission standard for passenger diesel cars(g/km)

Stage	Date	CO	HC	HC+NOx	NOx	PM
Euro I	1992.07	2.72 (3.16)	-	0.97 (1.13)	-	0.14 (0.18)
Euro II, ID	1996.01	1.0	-	0.7	-	0.08
Euro II, DI	1996.01	1.0	-	0.9	-	0.10
Euro III	2000.01	0.64	-	0.56	0.50	0.05
Euro IV	2005.01	0.50	-	0.30	0.25	0.025
Euro V(a)	2009.09	0.50	-	0.23	0.18	0.005
Euro V(b)	2011.09	0.50	-	0.23	0.18	0.005
Euro VI	2014.09	0.50	-	0.17	0.08	0.005

Introduction (Cont.)

This challenges are forced the world to develop alternative fuels:

- Ethanol
  - ✓ limited only to spark ignition engines
  - ✓Limited with only 15% blend due to its effects on engine parts
- Hydrogen based fuel cells
  - ✓Complexity of hydrogen production
  - ✓Storage and transport challenge
  - ✓High cost fuel cell production

Introduction (Cont.)

- Biodiesel – most convenient for diesel ne

Advantage of biodi

- ✓Easy portab
- ✓Global availa
- ✓Higher comb
- ✓Lower sulphu
- ✓Higher cetane ber and high biodegradability

We are working on:

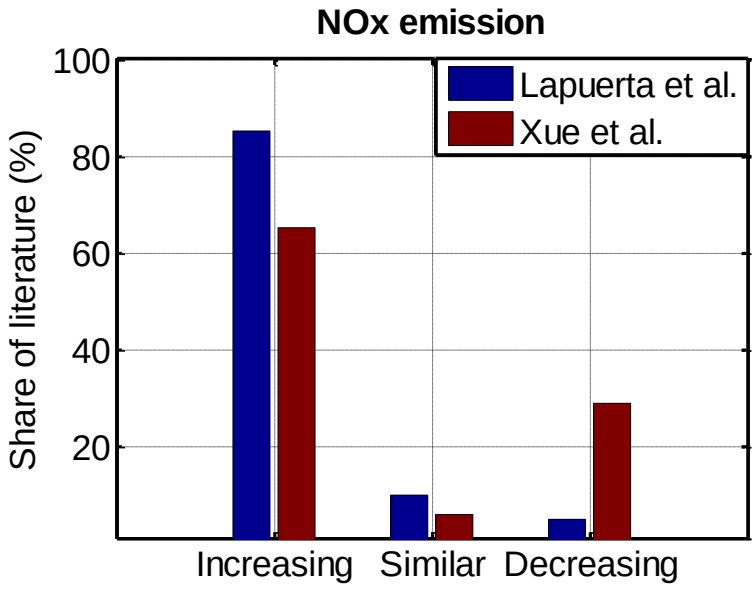
- Physical characterisation
- Combustion
- Performance
- Emission
- Engine life time

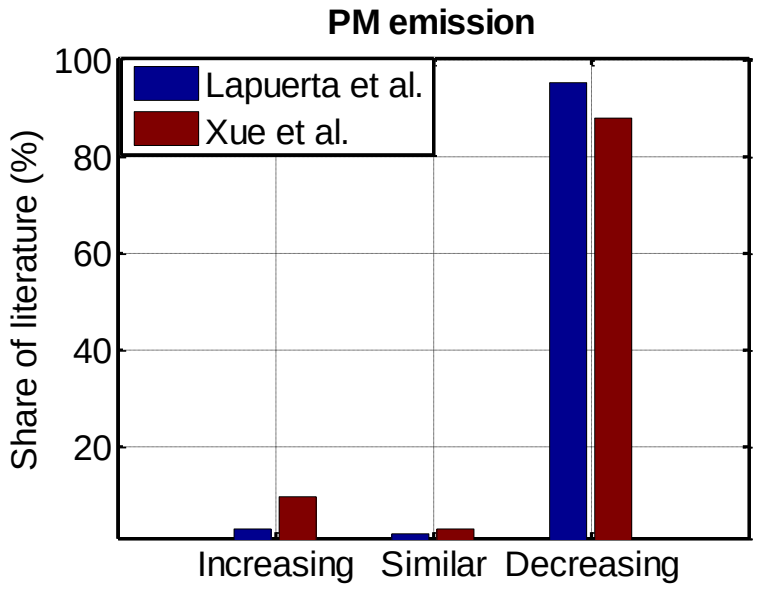
Selected publication

- **B. Tesfa**, R. Mishra, F. Gu, A.D. Ball (2013). 'Models for Predicting the Lower Heating Value of Biodiesel Blends', 2013, **Energy Conversation & Management** *Volume 71*, *Pages 217-226*
- **B. Tesfa**, R. Mishra, F. Gu, A. D. Ball (2013). 'Combustion and Performance Characteristics of CI Engine Running with Biodiesel', ***Energy***, *Volume 51*, *1 March 2013*, *Pages 101-115*
- **B. Tesfa**, R. Mishra, F. Gu, A.D. Ball (2012). 'Water Injection Effects on the Performance and Emission Characteristics of a CI Engine Operating with Biodiesel, **Renewable Energy,** 37 (1), pp. 333-344.
- D. Zhen, **B. Tesfa,** X. Yuan, R. Wang, F. Gu and A.D. Ball(2012). 'An investigation of the acoustic characteristics of a compression ignition engine operating with biodiesel blends' Journal of Physics: Conference Series, 364, p. 012015.
- **B. Tesfa,** R. Mishra, F. Gu and N. Powles (2010). 'Prediction Models for Density and Viscosity of Biodiesel and their Effects on Fuel Supply System in CI Engines'. **Renewable Energy,** 35(12).
- **B. Tesfa,** R. Mishra and F. Gu, G. Oliver (2010). 'Behaviour of a CI Engine Running by Biodiesel under Transient Conditions'. **SAE** 2010-01-1280.
- **B. Tesfa**, R. Mishra, F. Gu, A.D. Ball (2009). 'Condition Monitoring of CI engine running on Biodiesel using Transient Process'. **Key Engineering Materials**, 413-414. pp. 495-503.
- **B. Tesfa**, R. Mishra, F. Gu, A. D. Ball . 'NOx Emission Prediction Based on Cylinder Pressure Measurement for Engine Emission Monitoring', **COMDEM 2011** ISBN 0-9541307-2-3, Norway 30 May 1st Jun 2011.
- **B. Tesfa**, R. Mishra, F. Gu and A. D. Ball (2009), 'Performance of Compression Ignition (CI) Engine Running on Biodiesel during Transient Condition' In: Thirty Sixth National Conference on Fluid Mechanics and Fluid Power, 17-19 December 2009, Pune, India.
- **B. Tesfa**, R. Mishra, F. Gu and A. D. Ball (2009) 'Predicting specific gravity and viscosity of biodiesel fuels' In: Proceedings of Computing and Engineering Annual Researchers' Conference 2009: CEARC'09. University of Huddersfield, Huddersfield, pp. 38-44.
- **B. Tesfa**, R. Mishra, F. Gu and A. D. Ball (2009) Transient process modelling for condition monitoring of compression ignition (CI) engine. In: Proceedings of the 12th EAEC European Automotive Congress 2009. European Automotive Congress.

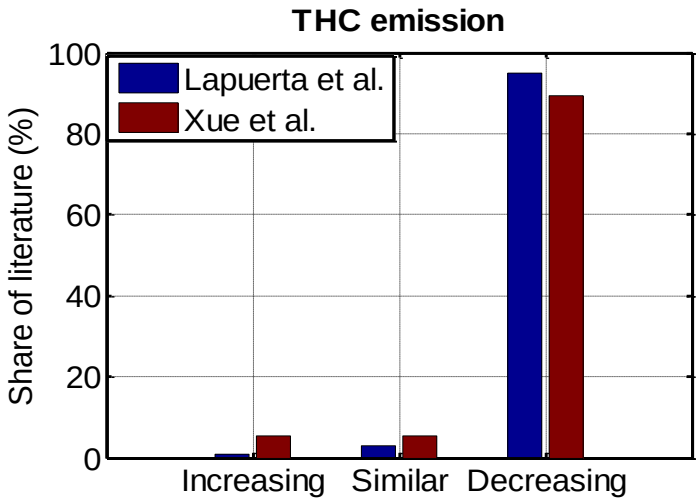
Introduction (Cont.)

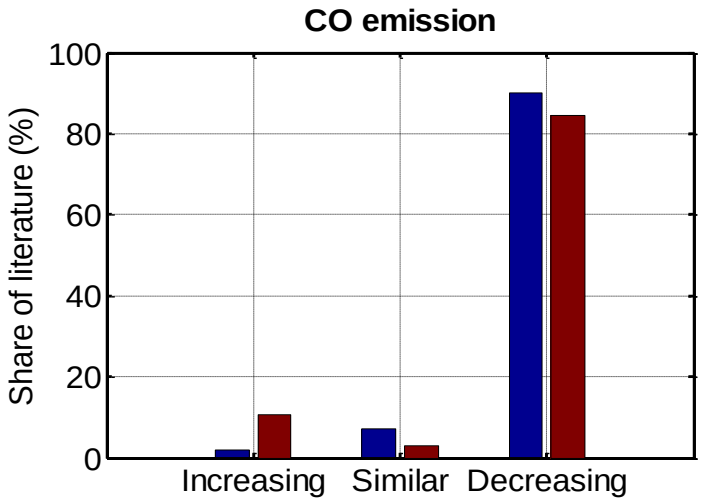
- Lapuerta et al. and Xue et al. reviewed 158 and 162 articles respectively about biodiesel engine performance and emissions, published by highly rated journals in scientific indexes covering up to 2008 and 2010.

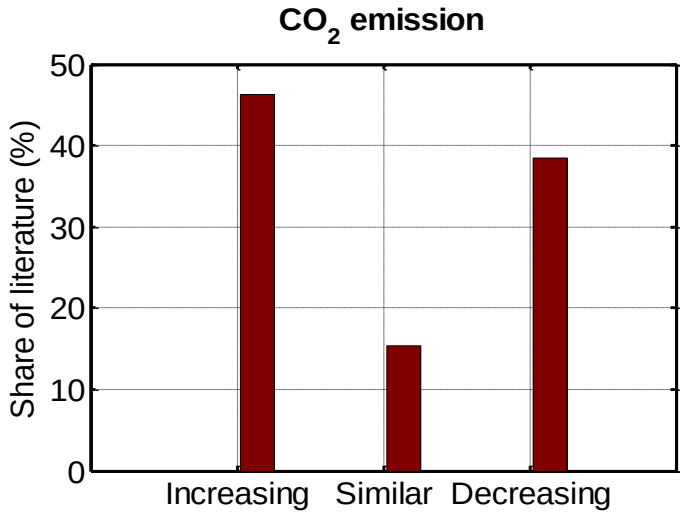




Introduction (Cont.)



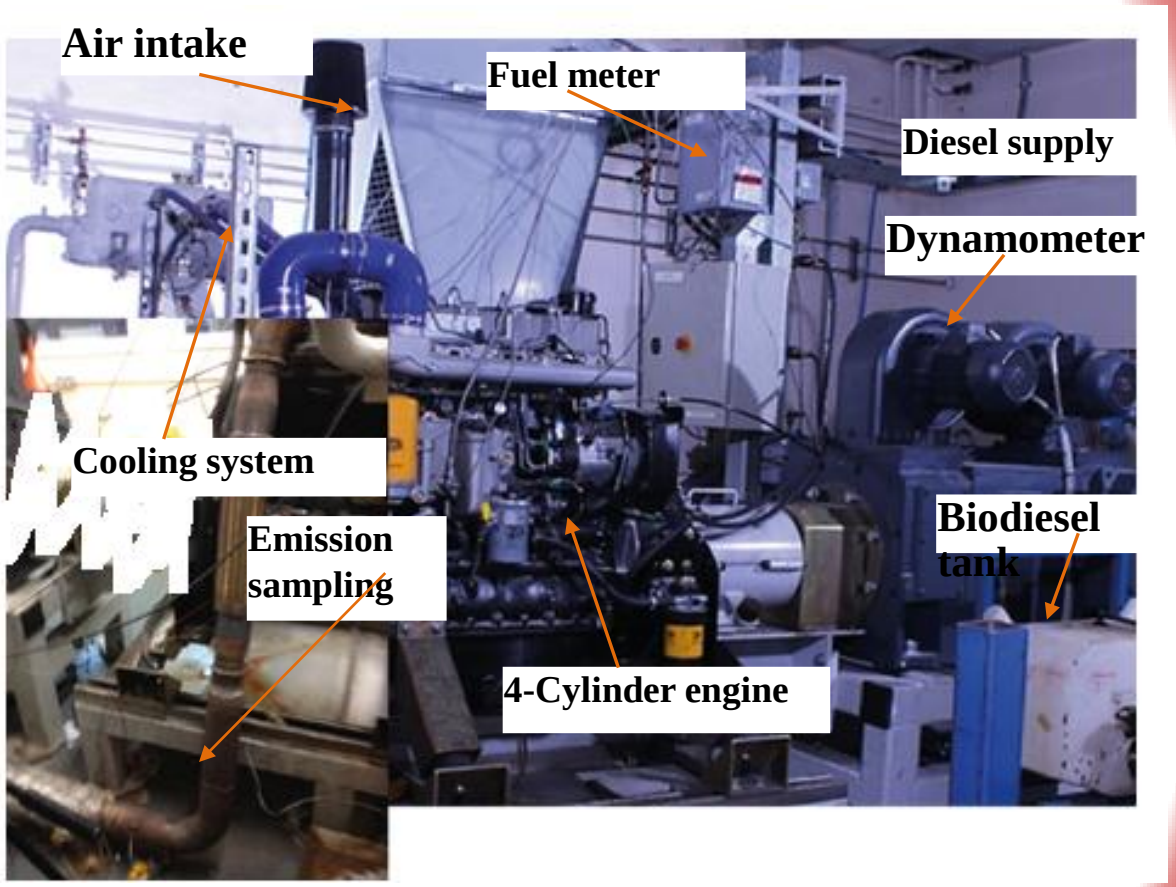




The objective of this study is to investigate the emission characteristics of CI engine running with biodiesel blend by varying biodiesel types and blends ratio for heavy duty engine.

Materials and Test Procedures

- A four-cylinder, four-stroke, turbo charged, water-cooled and direct-injection CI engine
- 4.4 litre capacity, 75kW
- The unit with a 200kW AC Dynamometer



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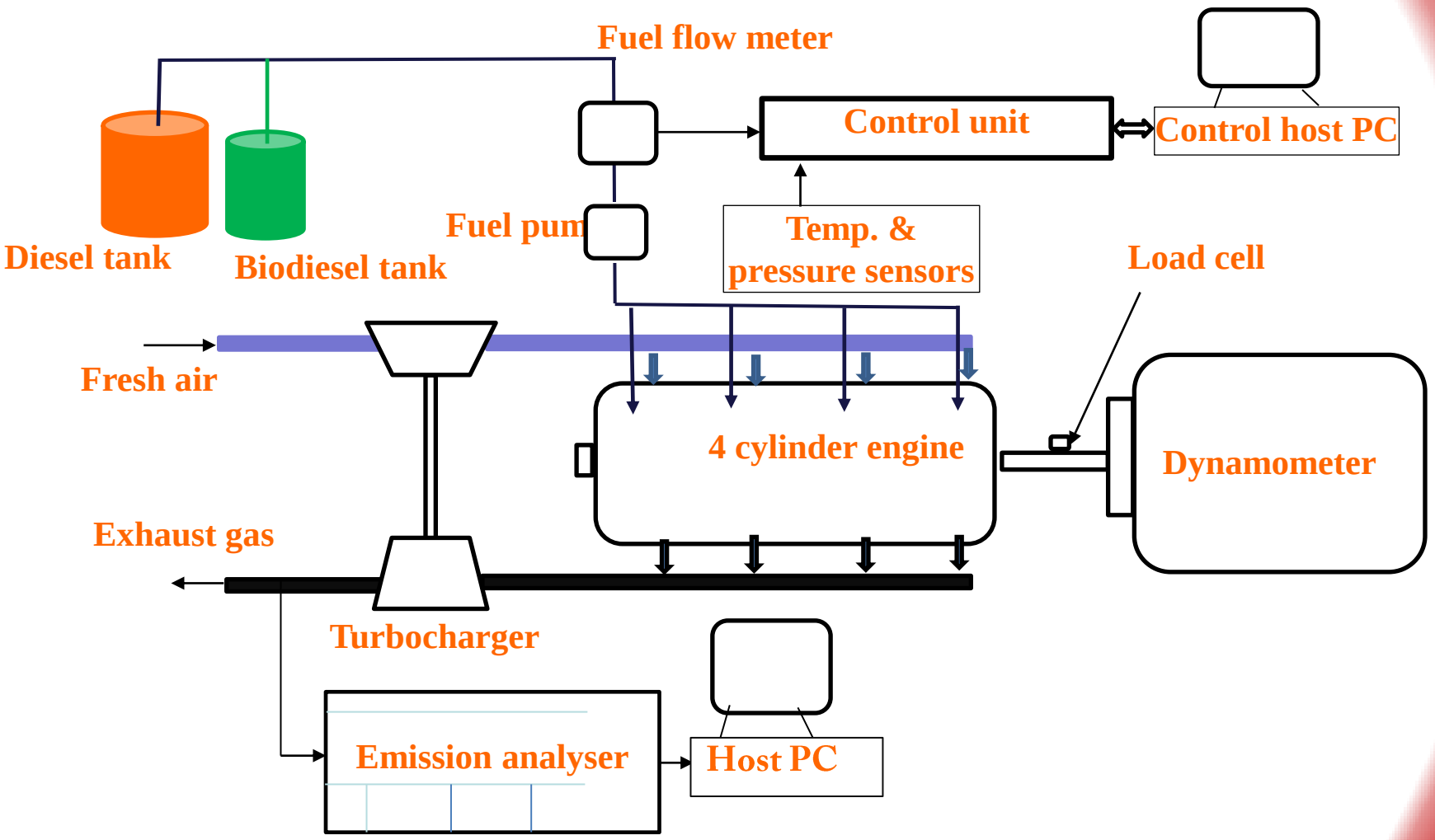


Materials and Test Procedures

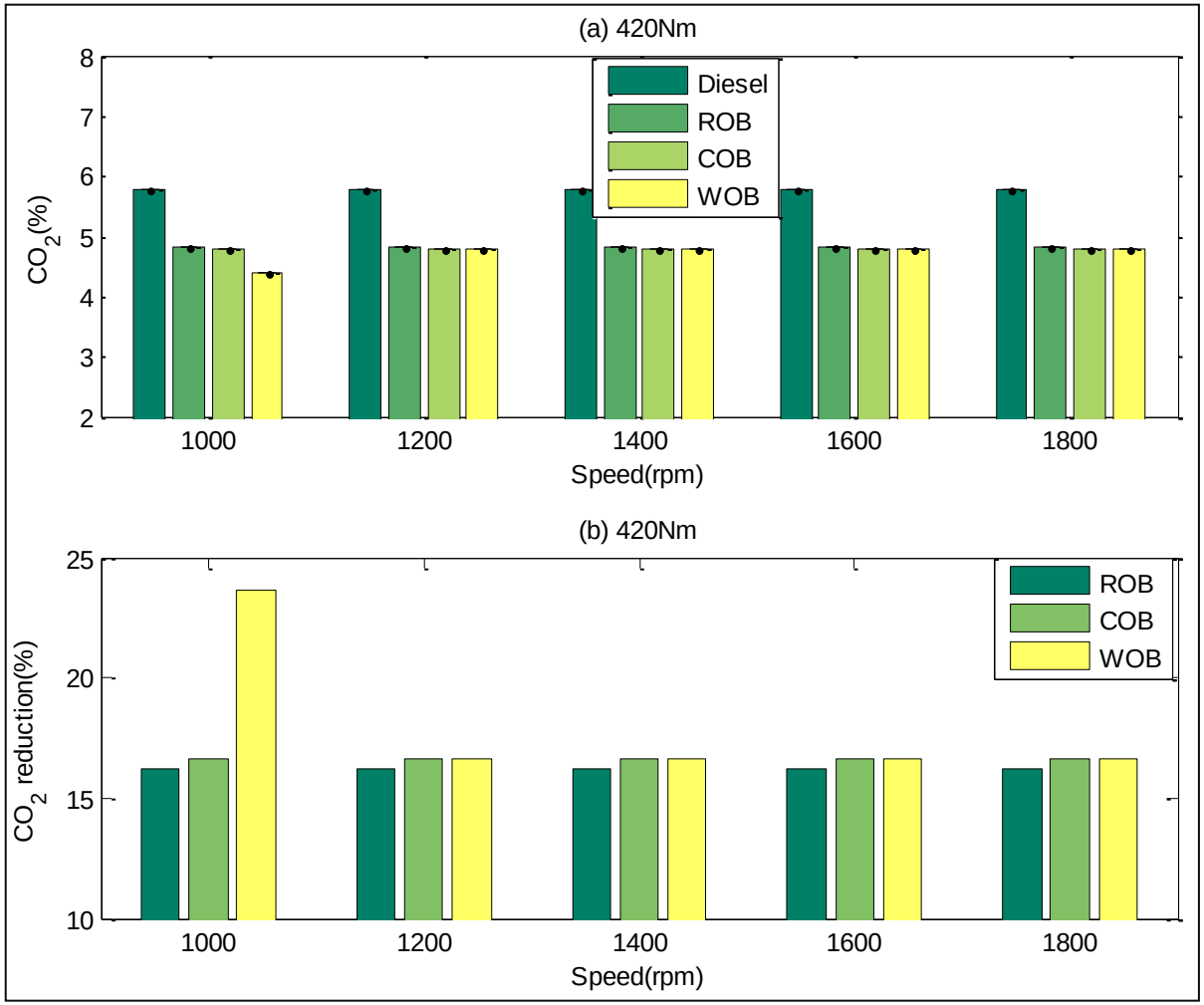
- Corn oil biodiesel, Rapeseed oil biodiesel, Waste oil biodiesel, Diesel and its blends were used

Property	Diesel (B0)	B10	B20	B50	B75	B100
Density (kg/m3)	853	859	865	871	872	879
LHV (MJ/kg)	42.67	42.26	41.84	40.58	39.54	38.50
Viscosity (mm2/s)	3.55	3.91	4.28	4.68	4.74	5.13

Materials and Test Procedures

- Preconditioning procedure at high speed and high load was implemented to purge any of the remaining effects from previous tests.
- The measurements of gaseous emissions were carried out using a gas test bench HORIBA.
- The sample line of the equipment is connected directly to the exhaust pipe and it is heated to maintain a wall temperature of around 191^{o}C and avoid the condensation of hydrocarbons into the line.
- The test was carried out for range of engine speeds (from 1000 to 1800rpm with 200rpm increment) and at maximum engine load (420Nm).

Effects of biodiesel source on emissions



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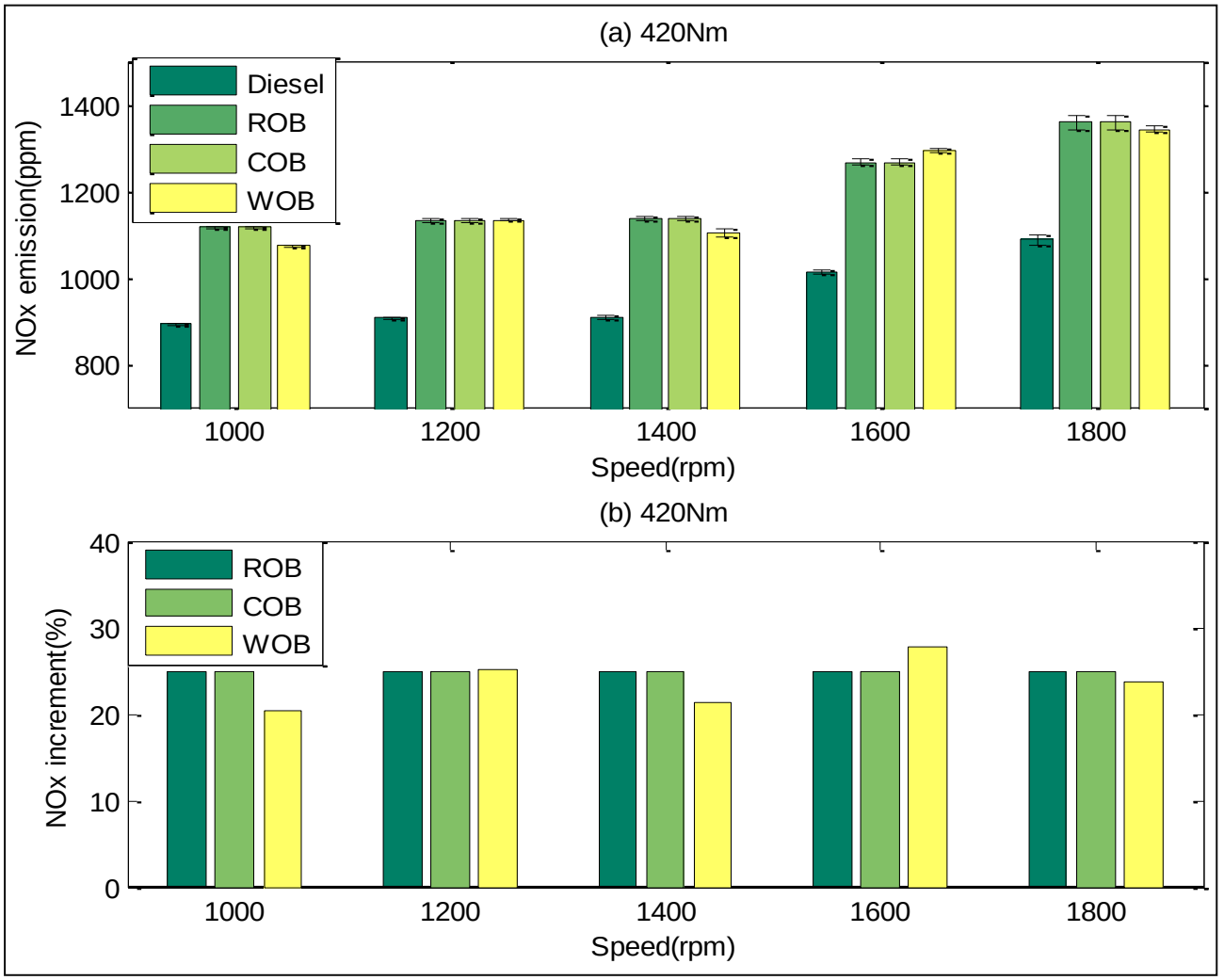

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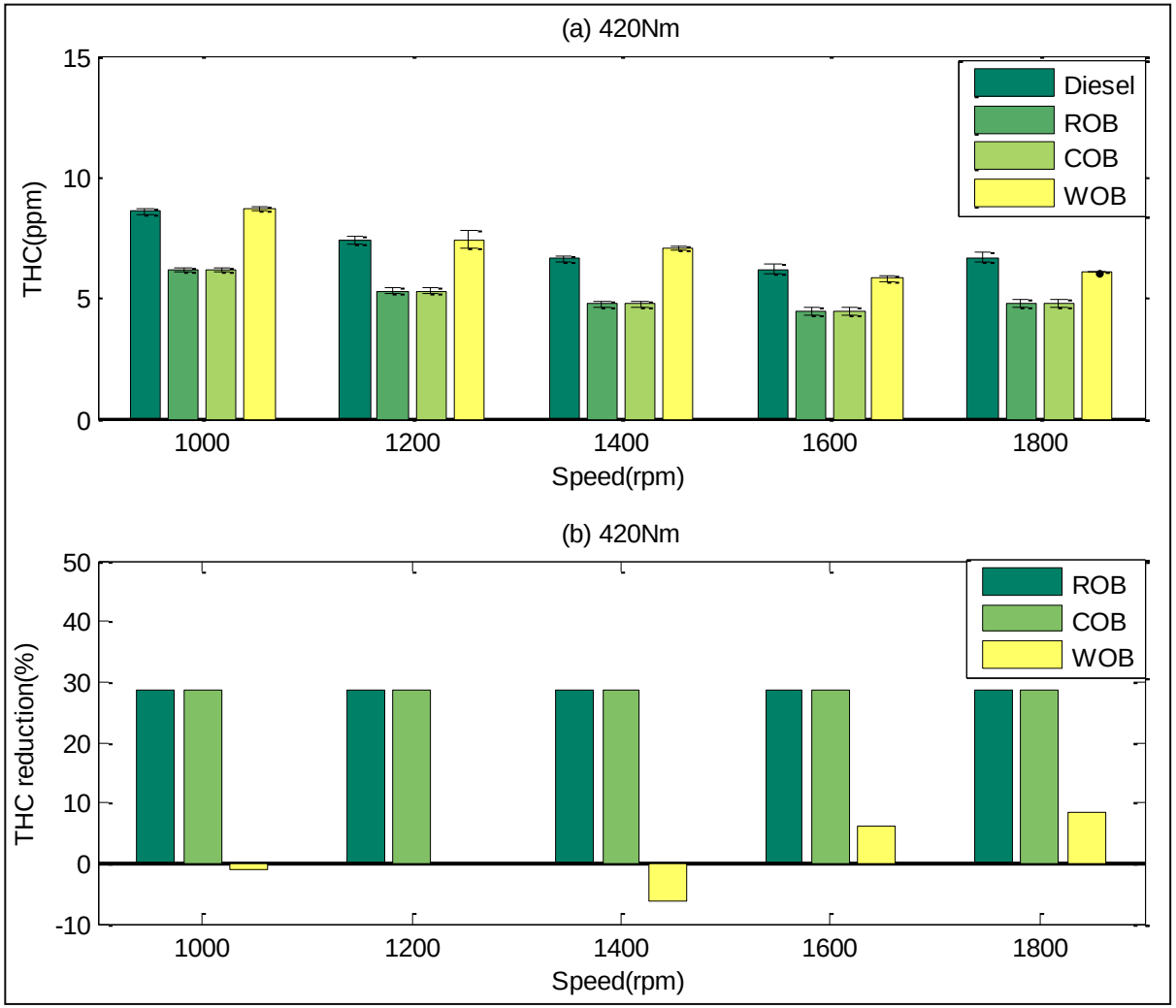

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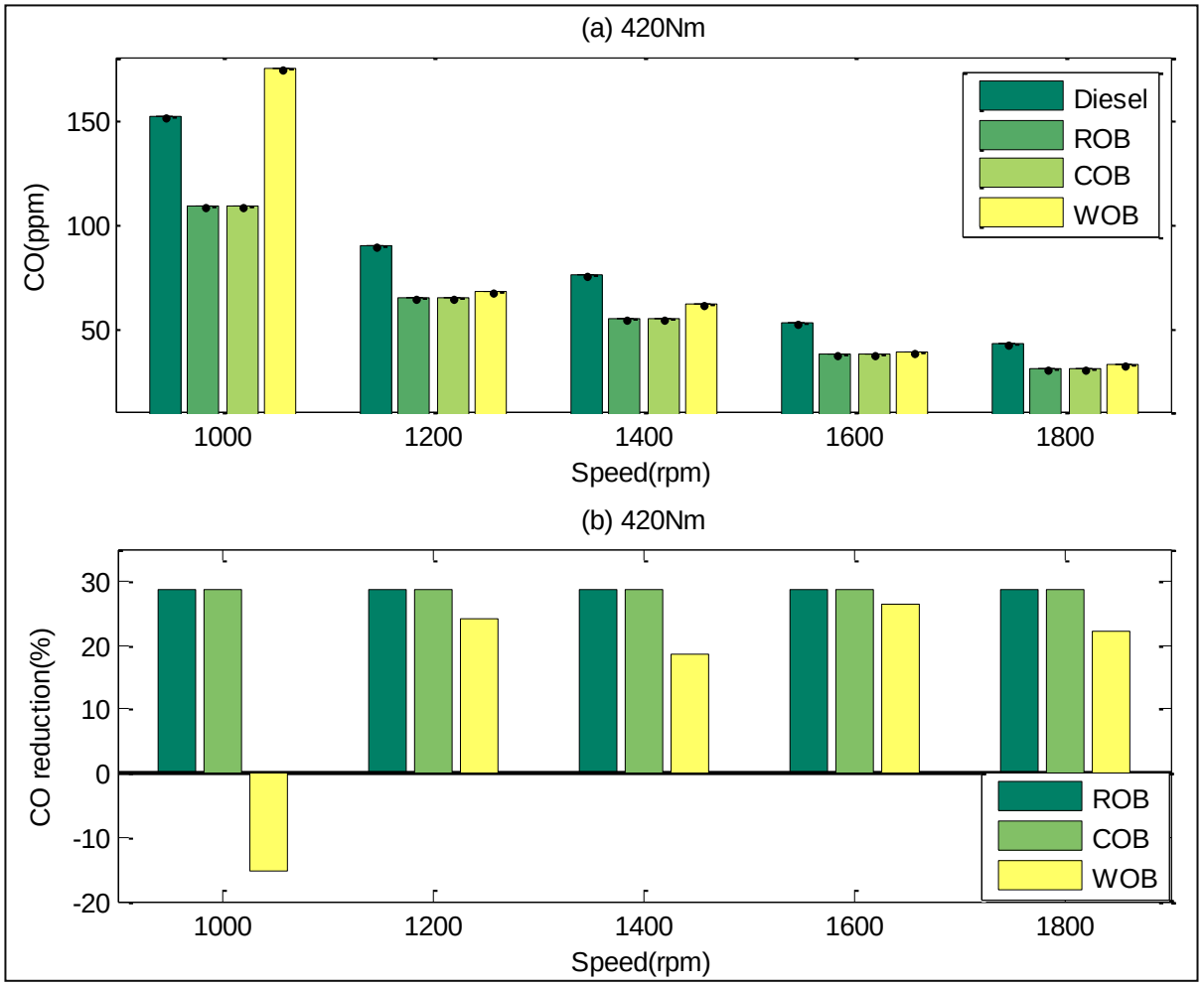
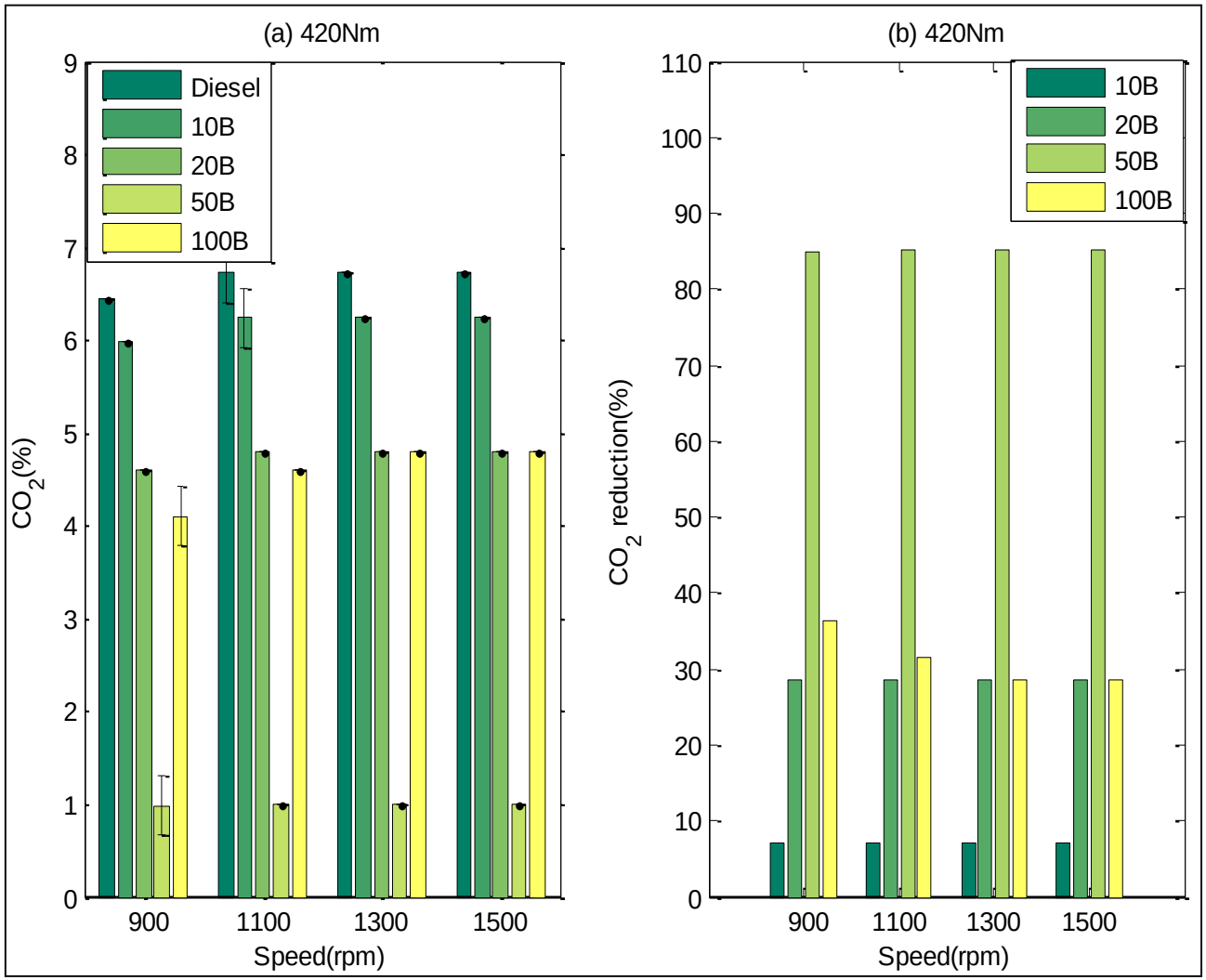


Effects of biodiesel blend fraction on emissions



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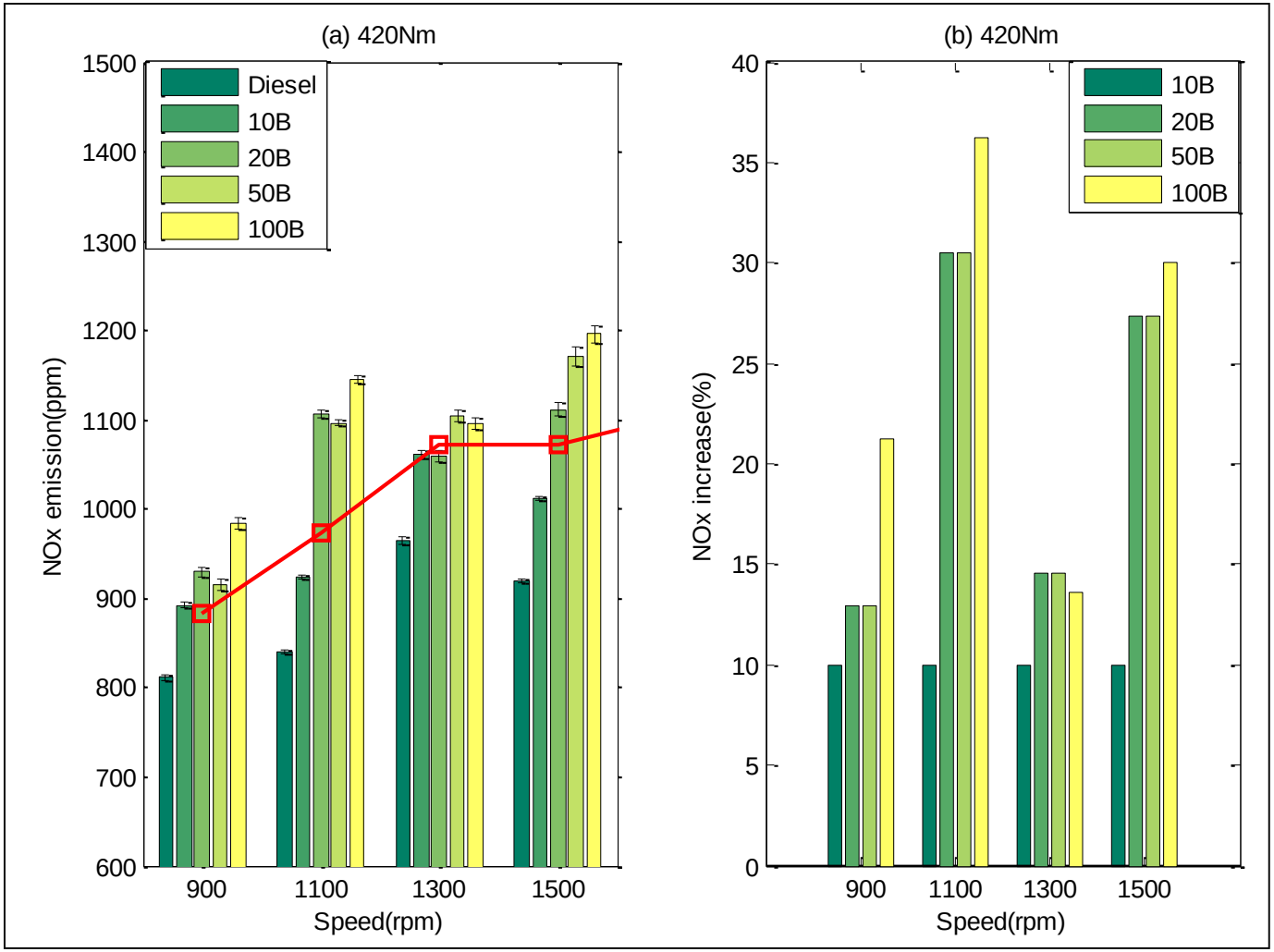

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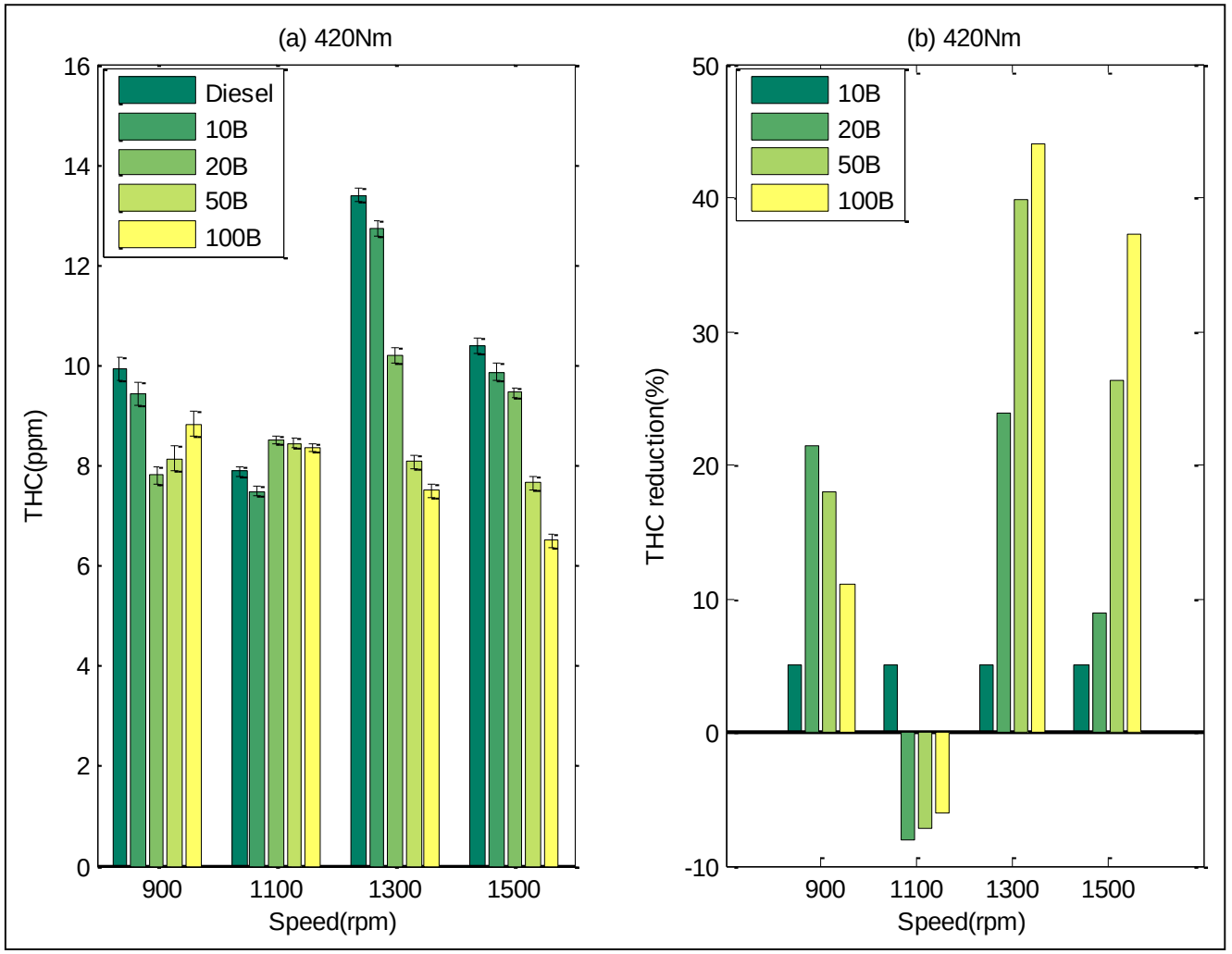

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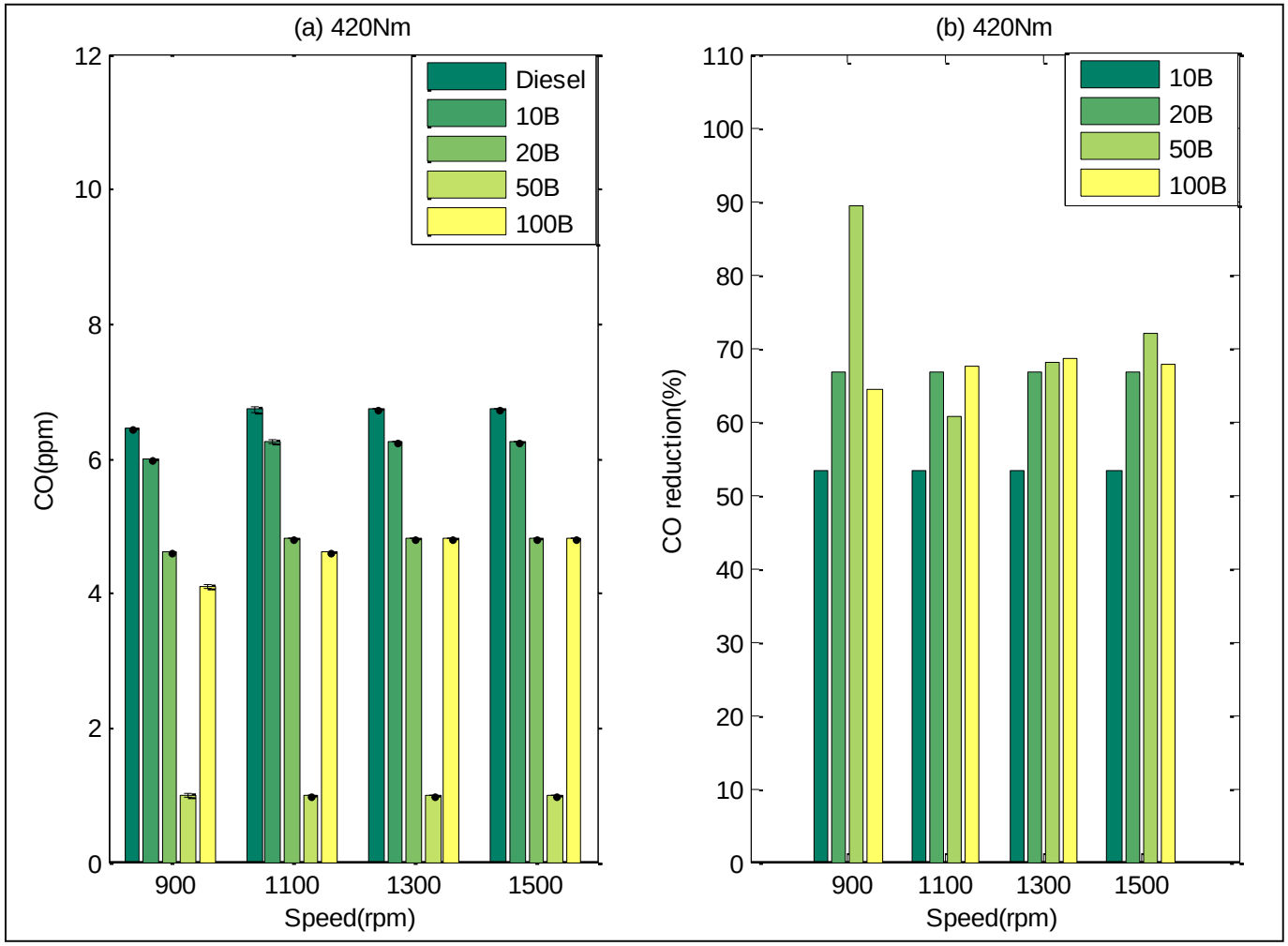

Conclusions

1. The source of biodiesel does not show significant effect on the CI engine's emissions (CO_2, CO, NOx and THC) as long as the fuel physical and chemical properties remain same.
2. The emission analyses of the CI engine running with biodiesel highlights a significant reduction in CO_2, CO and THC emission at working engine operation conditions.
3. It is also found that when the biodiesel content increases a further reduction in emissions is observed. This emission reduction is a result of the oxygen content in biodiesel and the low carbon hydrogen ratio.
4. For all biodiesel contents the NOx emission increases for all operating conditions during of the CI engine. This increase is mainly due to the higher oxygen content present in biodiesel and the advanced injection characteristics.

Thank you