

Ignition and combustion characteristics of biomass derived fast pyrolysis bio-oil in a combustion research unit

Citation for published version (APA):

Wang, Y., Han, J., Maes, N., & Somers, B. (2021). *Ignition and combustion characteristics of biomass derived fast pyrolysis bio-oil in a combustion research unit*. Poster session presented at 16th Conference on Sustainable Development of Energy, Water and Environment Systems, SDEWES 2021, Dubrovnik, Croatia.

Document license:

CC BY

Document status and date:

Published: 01/10/2021

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

[Link to publication](#)

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal.

If the publication is distributed under the terms of Article 25fa of the Dutch Copyright Act, indicated by the "Taverne" license above, please follow below link for the End User Agreement:

www.tue.nl/taverne

Take down policy

If you believe that this document breaches copyright please contact us at:

openaccess@tue.nl

providing details and we will investigate your claim.

Ignition and combustion characteristics of biomass derived fast pyrolysis bio-oil in a combustion research unit

Yu Wang*, Jinlin Han, Noud Maes, Bart Somers

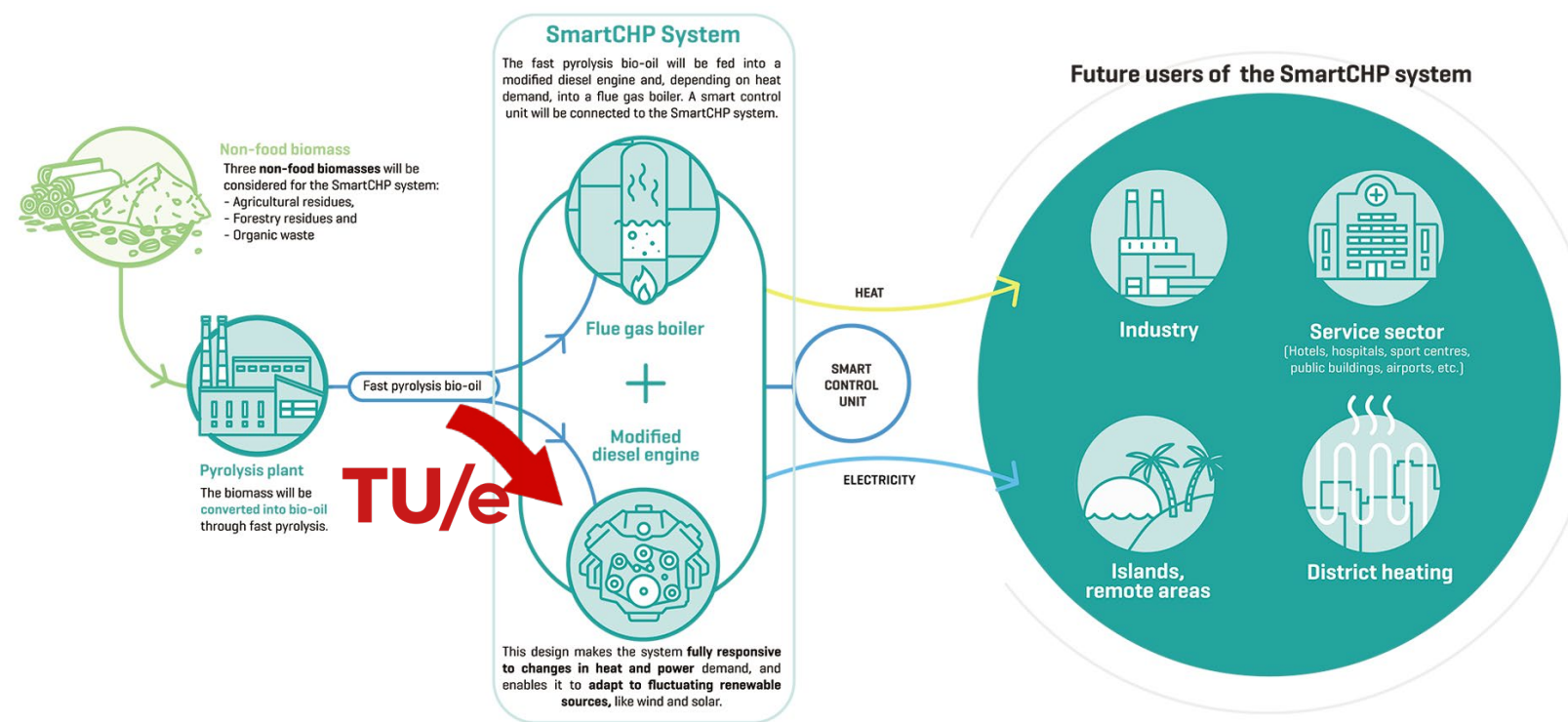
Department of Mechanical Engineering, Eindhoven University of Technology, The Netherlands

SmartCHP: aim and impact

- The EU research project SmartCHP will develop a novel, flexible small scale **cogeneration unit** to produce heat and electricity from **sustainable biomass**.
- The main technical novelty is the use of **fast pyrolysis bio-oil (FPBO)** from lignocellulosic biomass in a **converted diesel engine**.
- This will help boost the use of renewables in the electricity and heating & cooling sectors, contributing to the **2030 climate and energy targets**.

With a market potential of **€4 billion**, and an estimated **85 to 95% reduction in GHG emissions** compared to fossil fuels, the installation of the SmartCHP technology in Europe can help mitigate **climate change** by introducing more **renewables** while bringing **new jobs**.

SmartCHP process



Challenge: how to apply FPBO in a diesel engine.
Status quo: FPBO < 30%: FPBO+alcohol+(biodiesel, etc.) [1-2]
SmartCHP target: FPBO ≥ 70%: FPBO+alcohol; FPBO+Beraid

Diesel vs FPBO



Property	Diesel	FPBO*
LHV (MJ/kg)	42.6	16.4
Density (kg/L)	0.82	1.17
C (wt%)	85.0	42.8
H (wt%)	12.6	7.8
O (wt%)	-	49.2
Water (wt%)	-	24.1
Solid (wt%)	-	0.04
Viscosity (cSt at 40 °C)	2.7	21.0
Cetane number	54.8	-

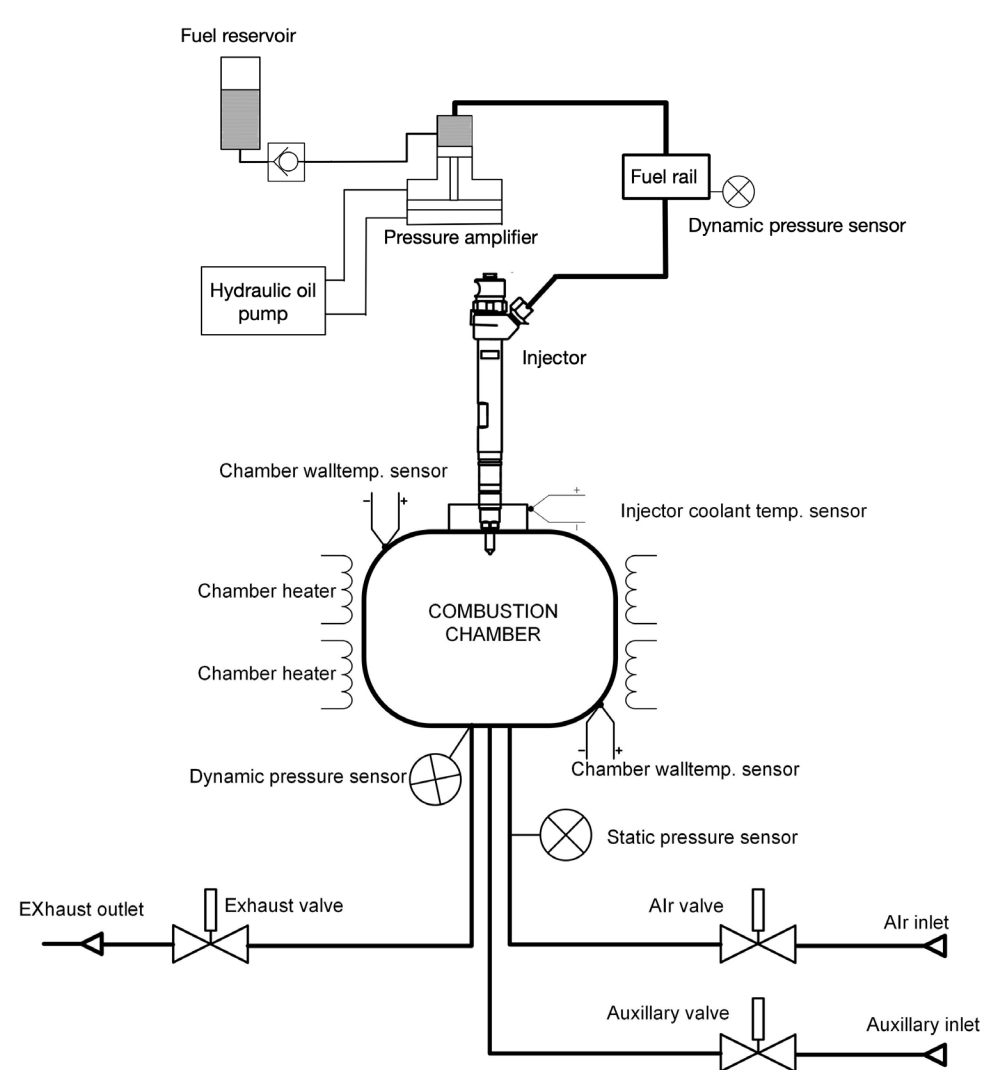
* Data from wood-based FPBO [3].

Experimental method

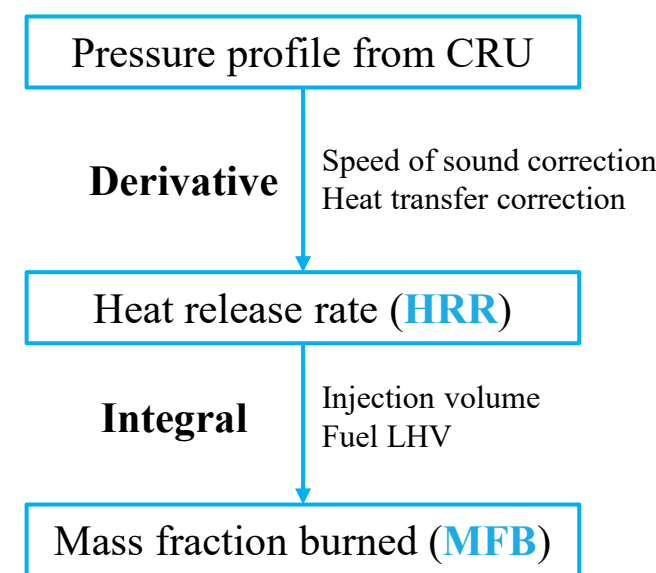
Combustion research unit (CRU)



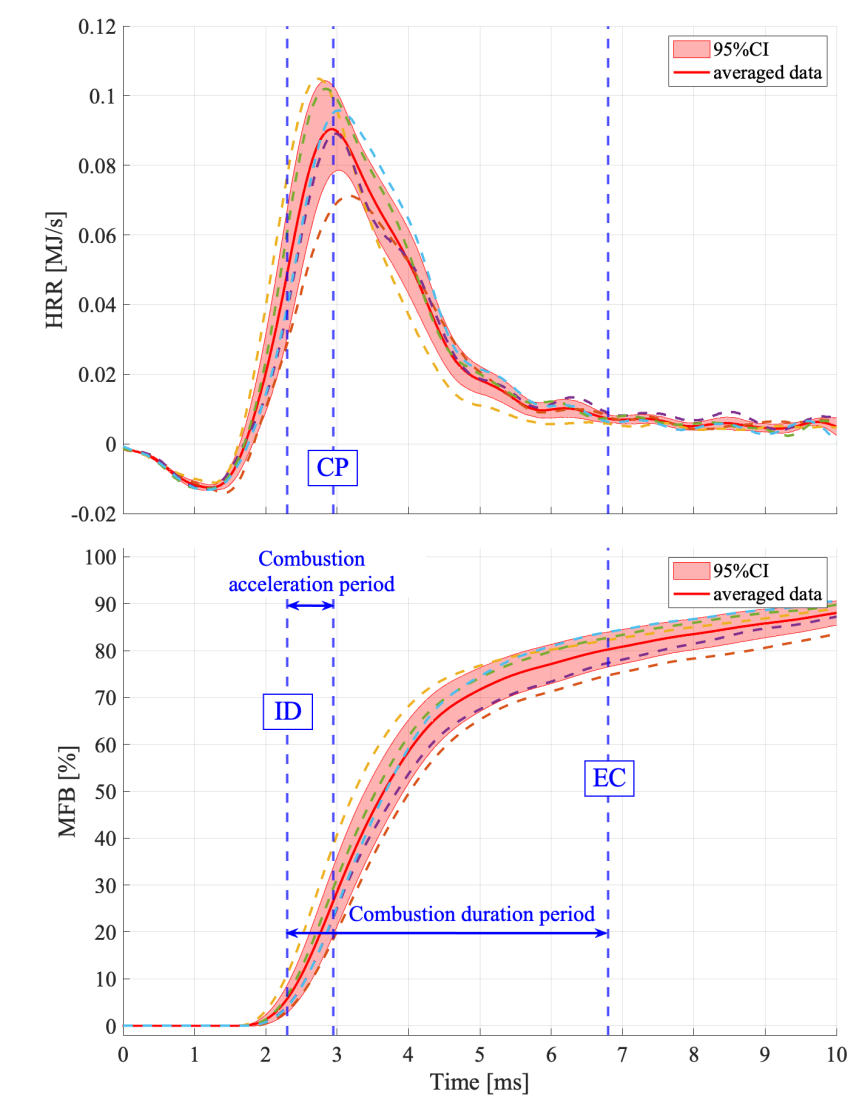
CRU operation condition	
Chamber volume [L]	0.475
Chamber wall temperature, T [°C]	300 – 590
Initial chamber pressure, P _{init} [bar]	10 – 70
Injection pressure, P _{inj} [bar]	200 – 1000
Injection duration [ms]	0 – 1.5



Data process & indicator definition



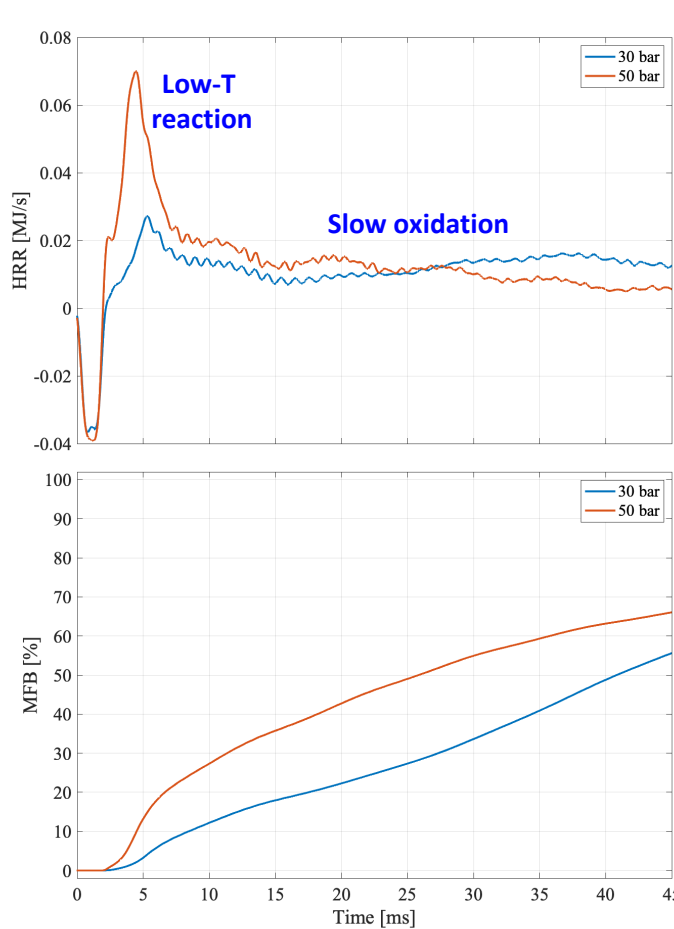
Indicator	Definition
Ignition delay, ID [ms]	5% MFB
Combustion phasing, CP [ms]	Maximum HRR
End of combustion, EC [ms]	80% MFB
Combustion acceleration period [ms]	Between ID and CP (CP-ID)
Combustion duration period [ms]	Between ID and EC (EC-ID)



Results and conclusions

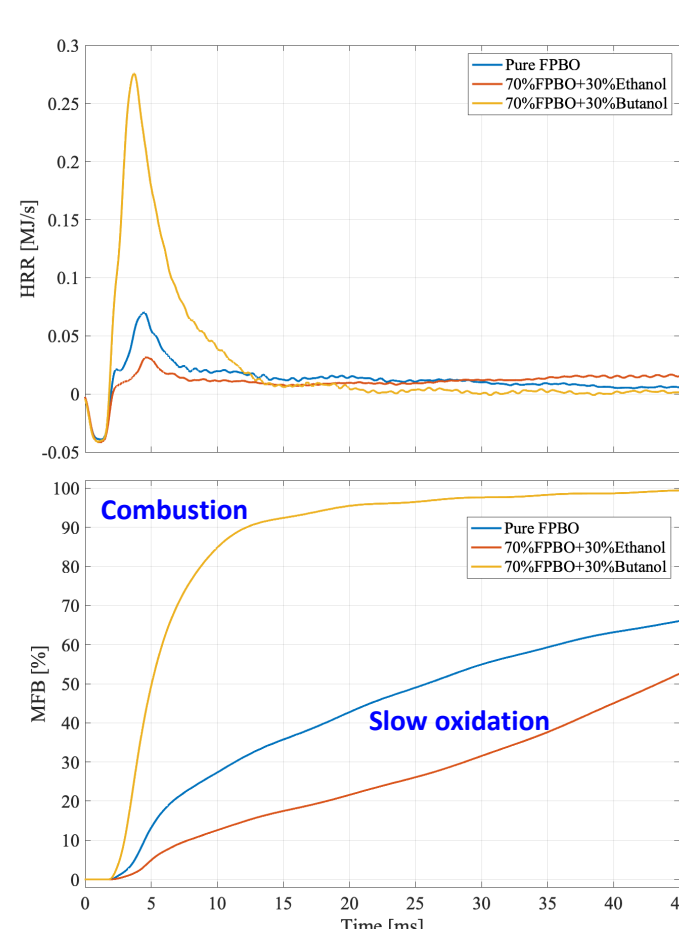
Pure FPBO

T=590 °C, P_{inj}=1000 bar



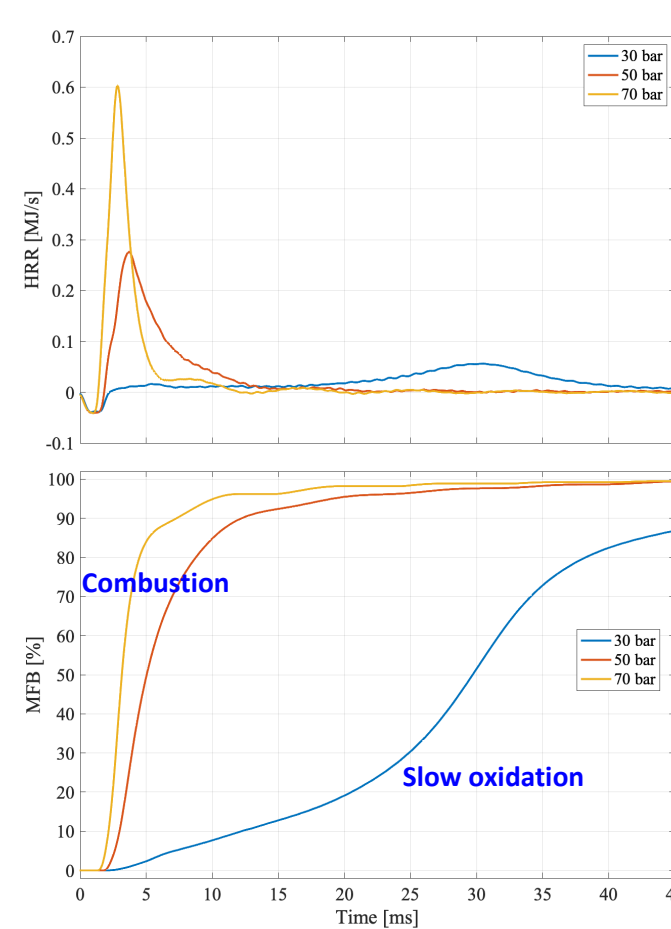
Effects of alcohol addition

T=590 °C, P_{init}=50 bar, P_{inj}=1000 bar



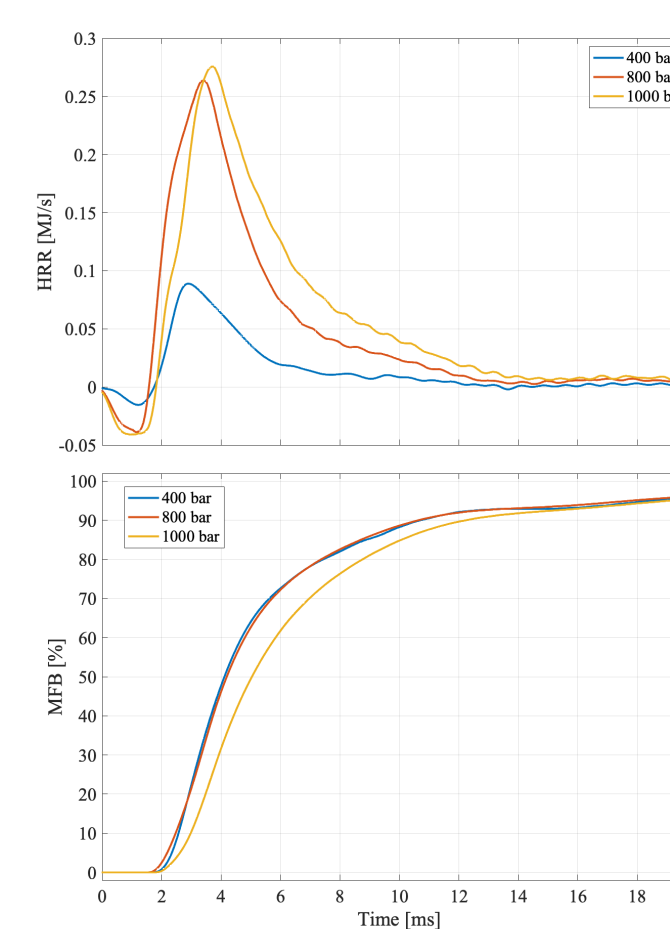
Effects of P_{init}

T=590 °C, P_{inj}=1000 bar



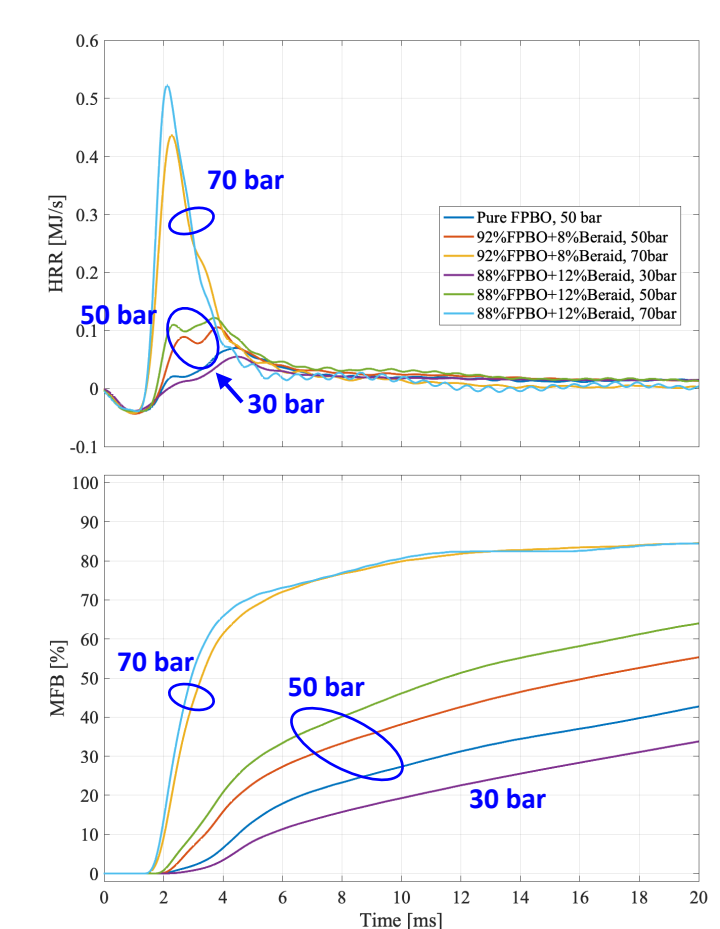
Effects of P_{inj}

T=590 °C, P_{init}=50 bar



Effects of Beraid addition

T=590 °C, P_{inj}=1000 bar



FPBO ignitability: between ethanol (CN ~7) and n-butanol (CN 17)

- Compared with ethanol, adding 30% n-butanol could significantly improve the ignition and combustion processes of FPBO.

Chamber pressure & injection pressure

- For 70%FPBO+30%Butanol, higher chamber pressure boosts ignition and combustion processes.
- Once the autoignition succeeds, the intense combustion (maximum HRR) arrivals within around 1 ms.
- Burn duration decreases with higher chamber pressure, while increases with higher injection pressure.

Ignition improver: Beraid is unqualified for FPBO

- When adding 12% Beraid to FPBO, the improvement in ignition behavior is very limited.

References

- Y. Wang, et al. (2021). Ignition and combustion characteristics of n-butanol and FPBO/n-butanol blends with addition of ignition improver. 10th European Combustion Meeting.
- S. Lee, et al. (2020). Combustion and emission characteristics of a diesel-powered generator running with N-butanol/coffee ground pyrolysis oil/diesel blended fuel. *Energy*, 206, 118201.
- B. Beld, et al. (2018). The use of a fast pyrolysis oil-Ethanol blend in diesel engines for CHP applications. *Biomass and bioenergy*, 110, 114-122.