

# 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.

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**Document status and date:**

Published: 01/10/2021

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

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

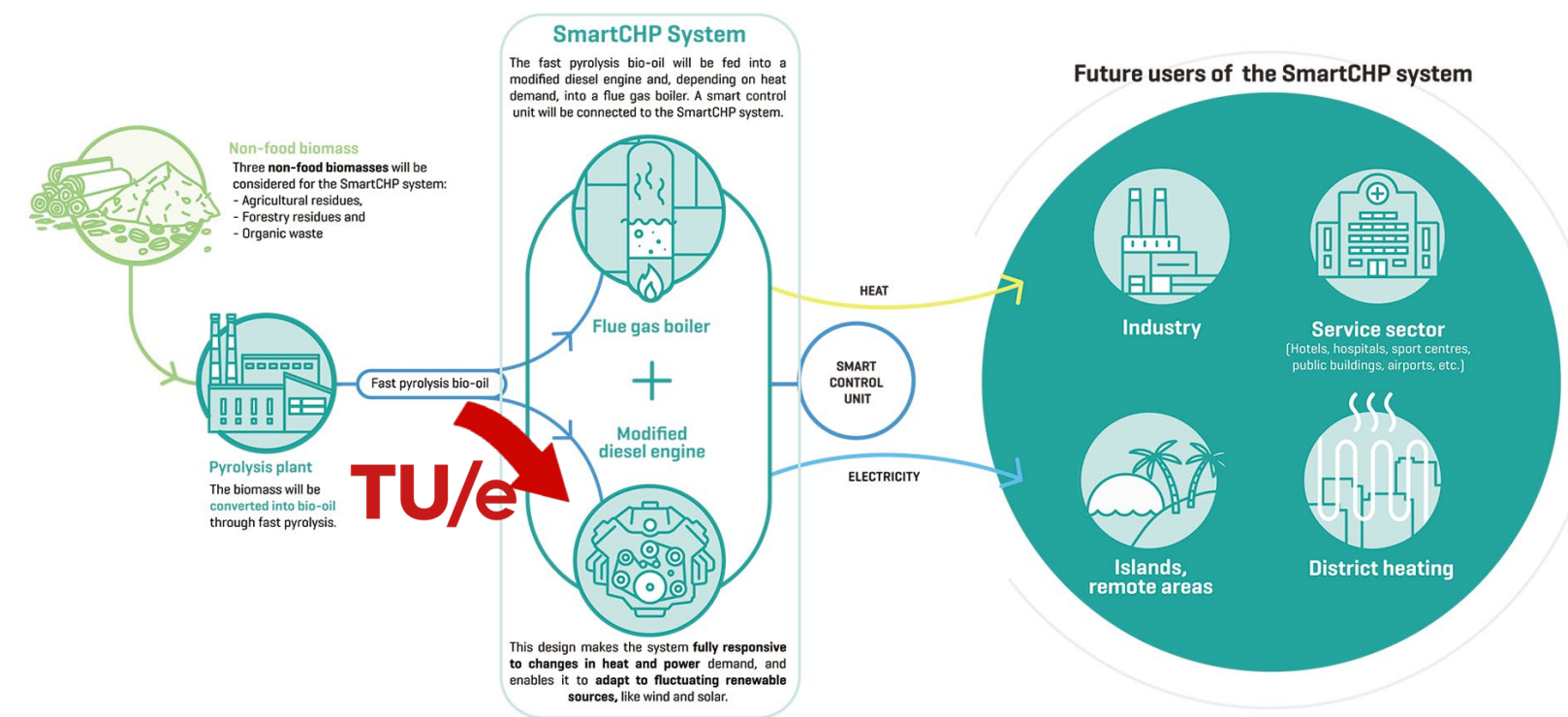
Department of Mechanical Engineering, Eindhoven University of Technology, The Netherlands

## 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	-

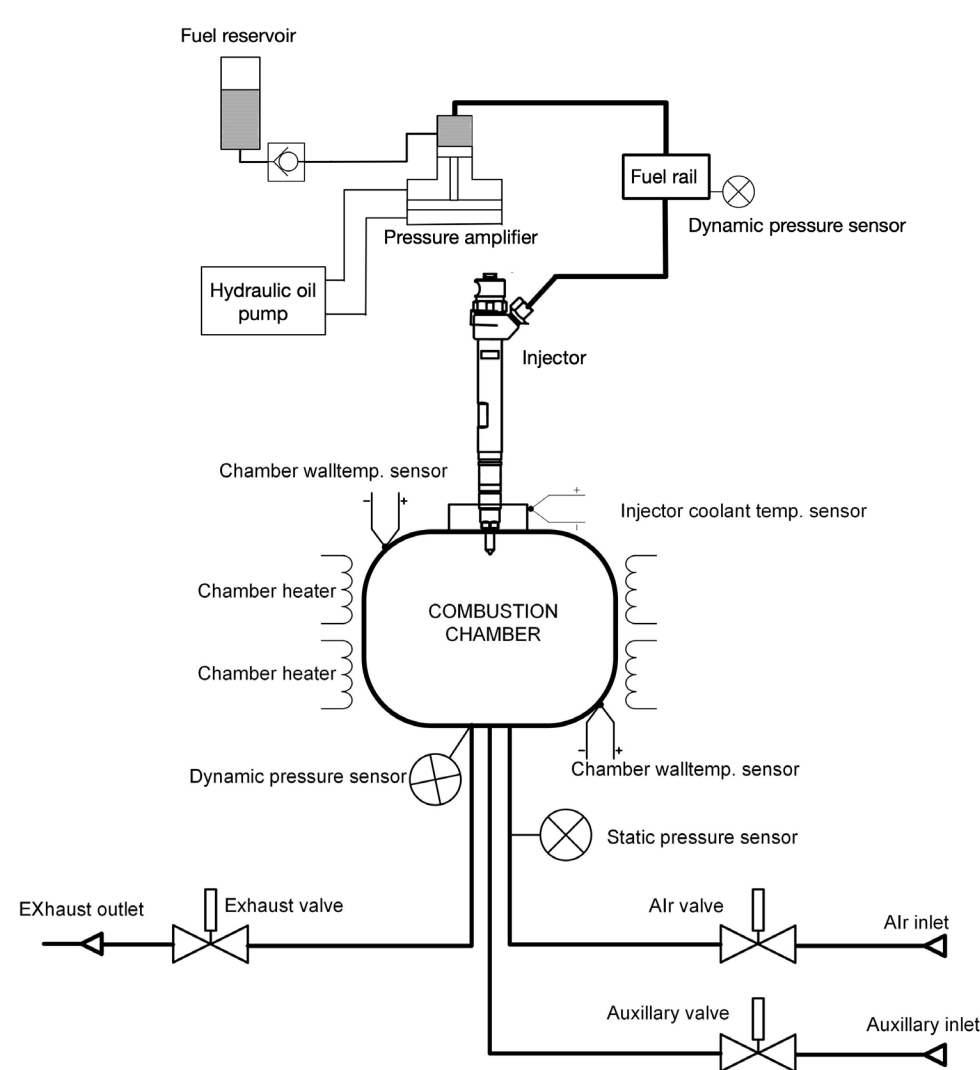
\* Data from wood-based FPBO [3].

## Experimental method

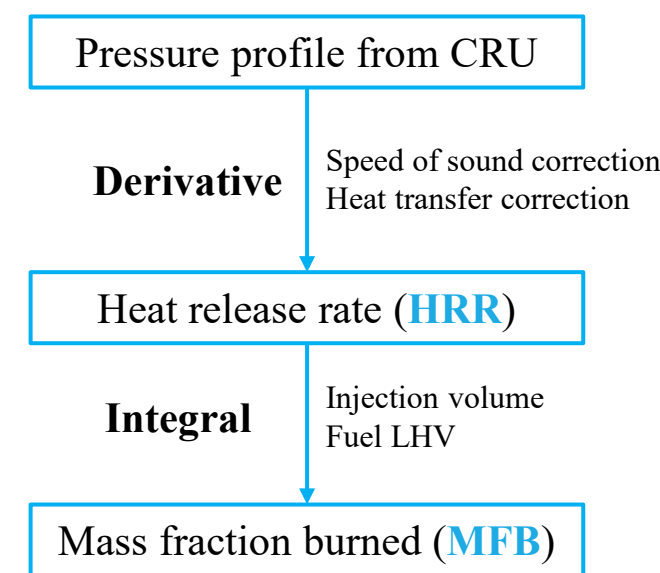
### Combustion research unit (CRU)



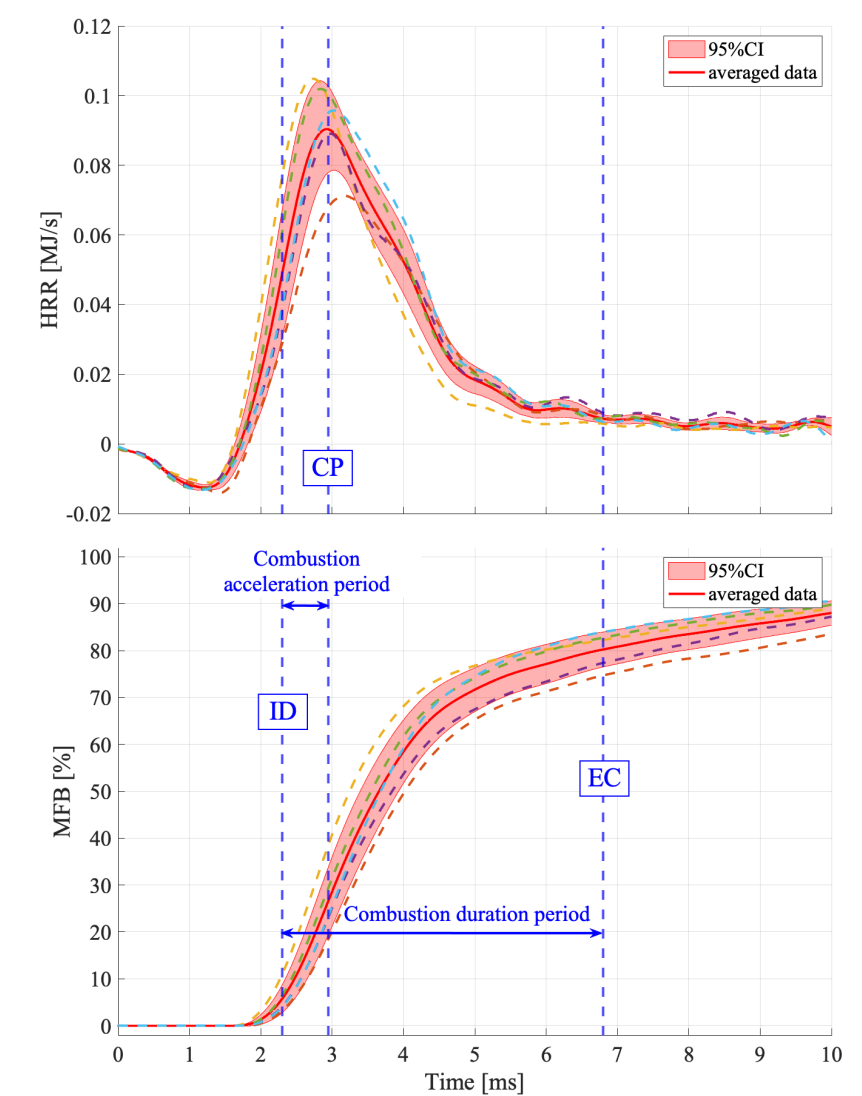
CRU operation condition	
Chamber volume [L]	0.475
Chamber wall temperature, T [°C]	300 – 590
Initial chamber pressure, P <sub>init</sub> [bar]	10 – 70
Injection pressure, P <sub>inj</sub> [bar]	200 – 1000
Injection duration [ms]	0 – 1.5



## Data process & indicator definition



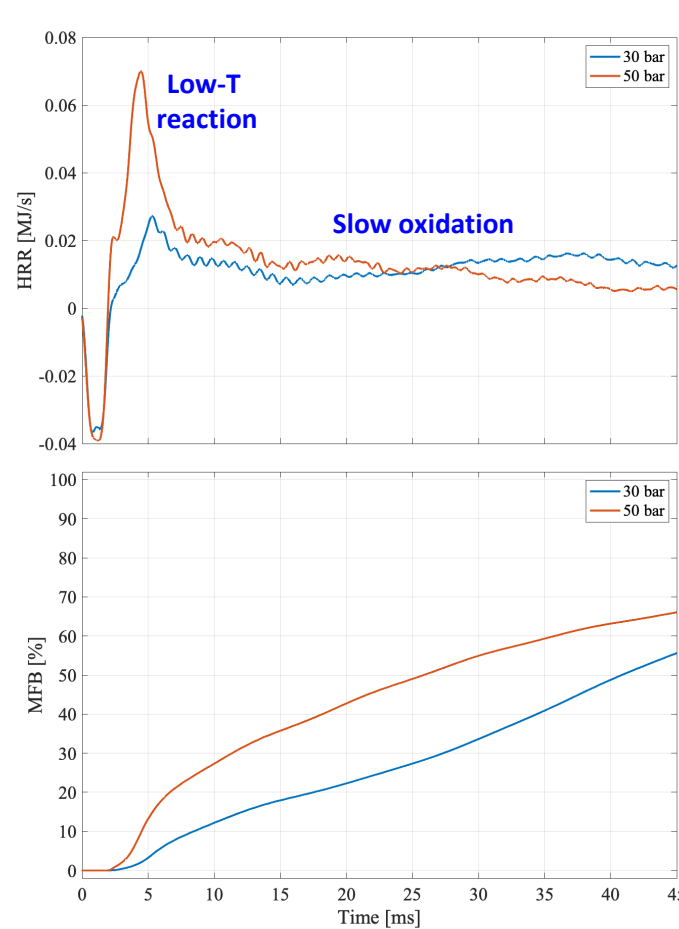
Indicator	Definition
Ignition delay, ID [ms]	5% MFB
Combustion phasing, CP [ms]	Maximum HRR
End of combustion, EC [ms]	80% MFB
Combustion acceleration period [ms]	Between ID and CP (CP-ID)
Combustion duration period [ms]	Between ID and EC (EC-ID)



## Results and conclusions

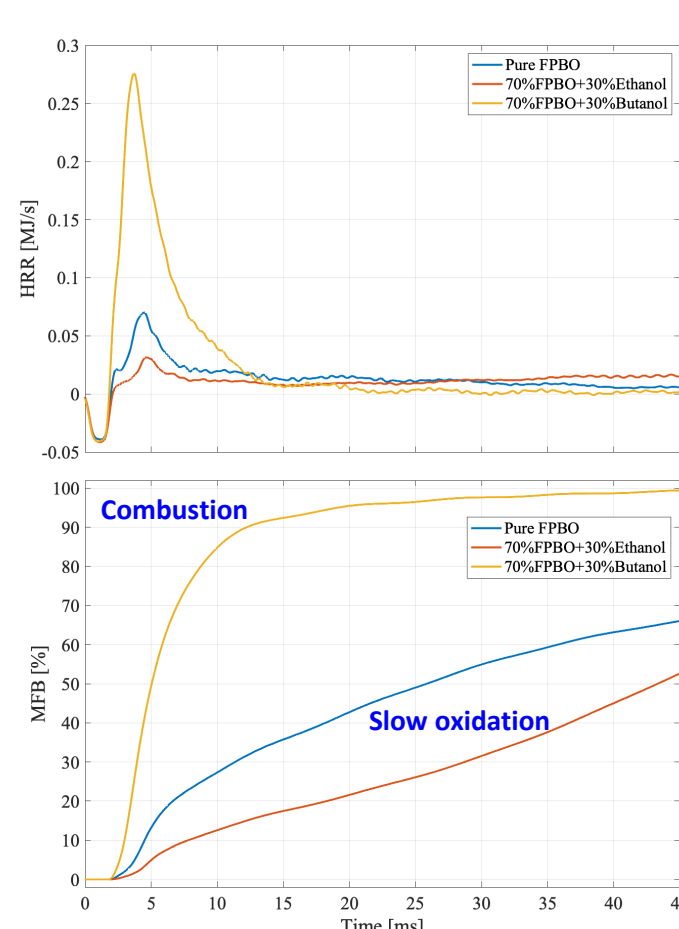
### Pure FPBO

T=590 °C, P<sub>inj</sub>=1000 bar



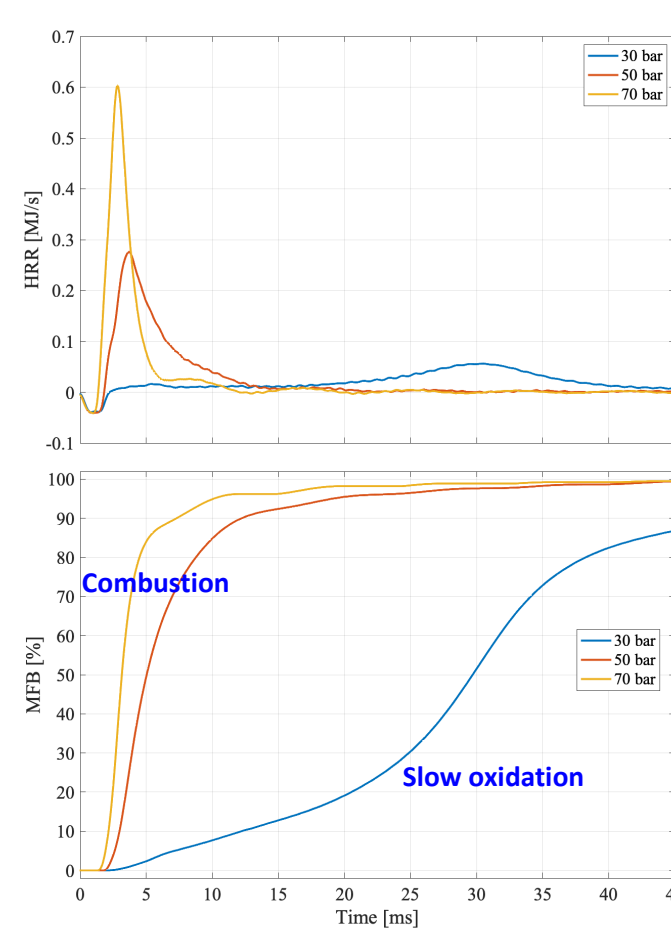
### Effects of alcohol addition

T=590 °C, P<sub>init</sub>=50 bar, P<sub>inj</sub>=1000 bar



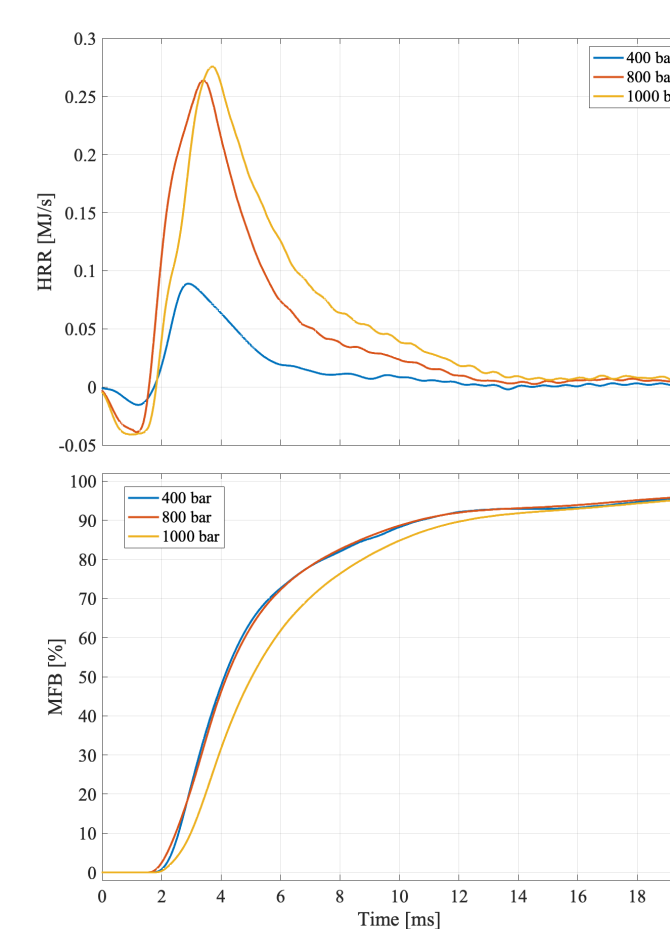
### Effects of P<sub>init</sub>

T=590 °C, P<sub>inj</sub>=1000 bar



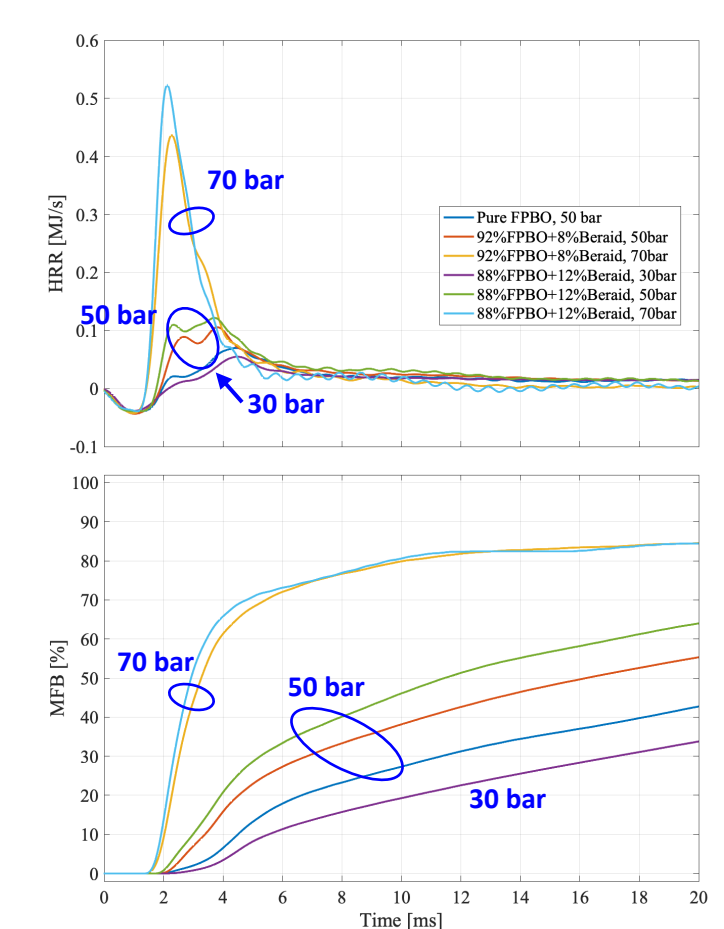
### Effects of P<sub>inj</sub>

T=590 °C, P<sub>init</sub>=50 bar



### Effects of Beraid addition

T=590 °C, P<sub>inj</sub>=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

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- 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.