

# CAHEMA WP3

## Engine Experiments

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**kick-off meeting**



Aalto University  
School of Engineering

Ossi Kaario

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# Introduction

- The aim of WP3 is to experimentally characterize ammonia ( $\text{NH}_3$ ) combustion in engines
- Motivation
  - No carbon  $\rightarrow$  no  $\text{CO}_2$
  - No carbon  $\rightarrow$  no soot
- Possible challenges
  - Very low flame speed. Hydrogen could enhance the situation.
  - Very high autoignition temperature. Pilot ignition is one solution.
  - NOx emissions
  - Low viscosity, gas below 10 bar. Injection/injector problems ?

# Previous Results

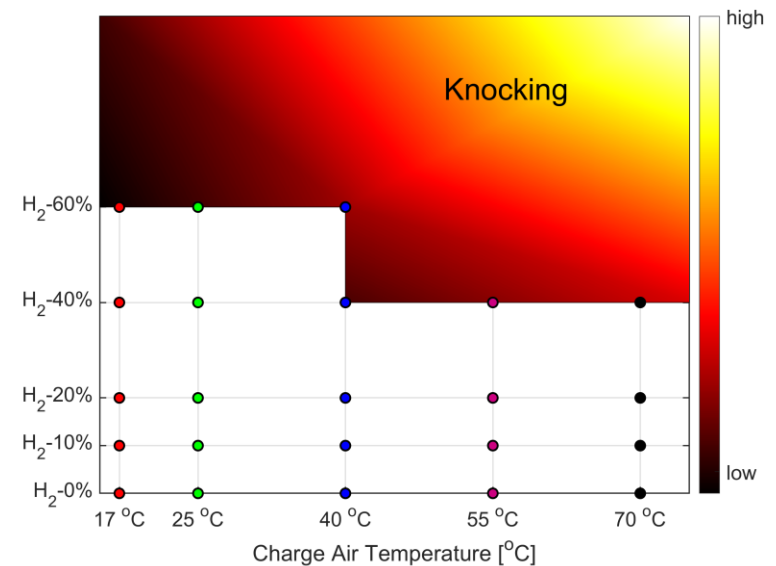
- We have lately focused on Tri-Fuel (TF) combustion by using  $\text{CH}_4$ -  $\text{H}_2$  mixture as the main fuel ignited by a diesel pilot

Table 1. Test engine specifications

Engine type	4-Stroke modified single-cylinder diesel engine
Bore	111 mm
Stroke	145 mm
Swept volume	1402 cm <sup>3</sup>
Combustion bowl	89.8 cm <sup>3</sup>
Vol. compression ratio	16.7:1
Swirl ratio	2.7
Pilot injection system	Bosch piezo CRI3 common rail
Injector no. of holes x diameter	3 x 0.160 mm (symmetric)
Pilot injection pressure	1000 bar
Port fuel injection system	2 x Bosch NGI injectors
Valve system	Electrohydraulic valve actuator

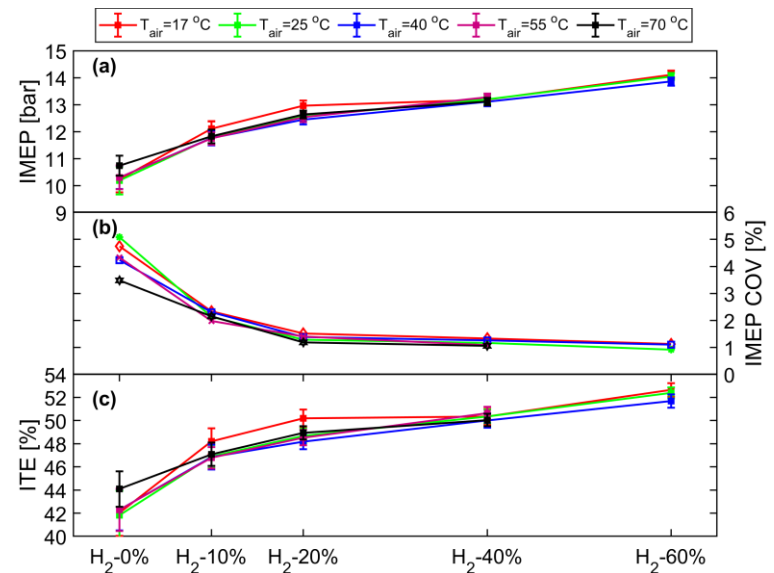
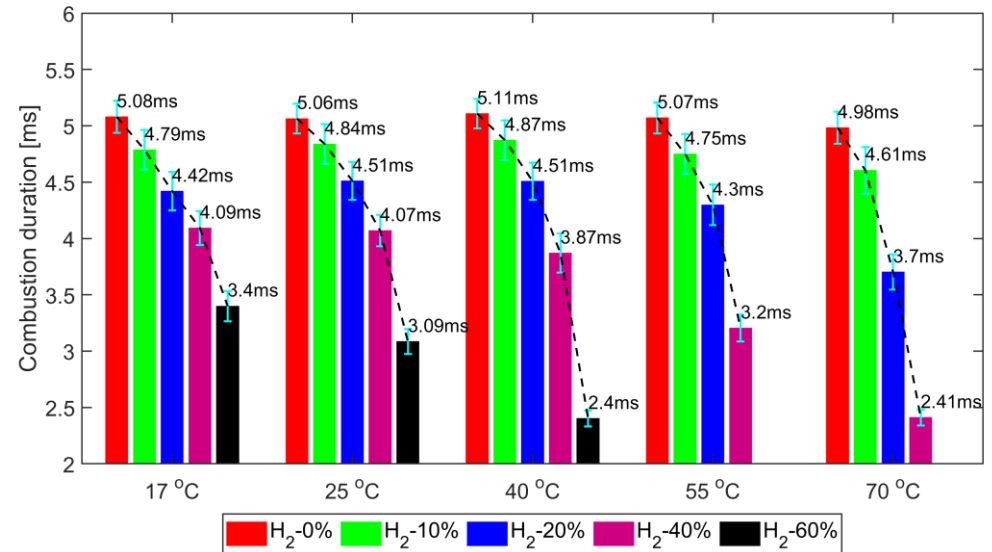
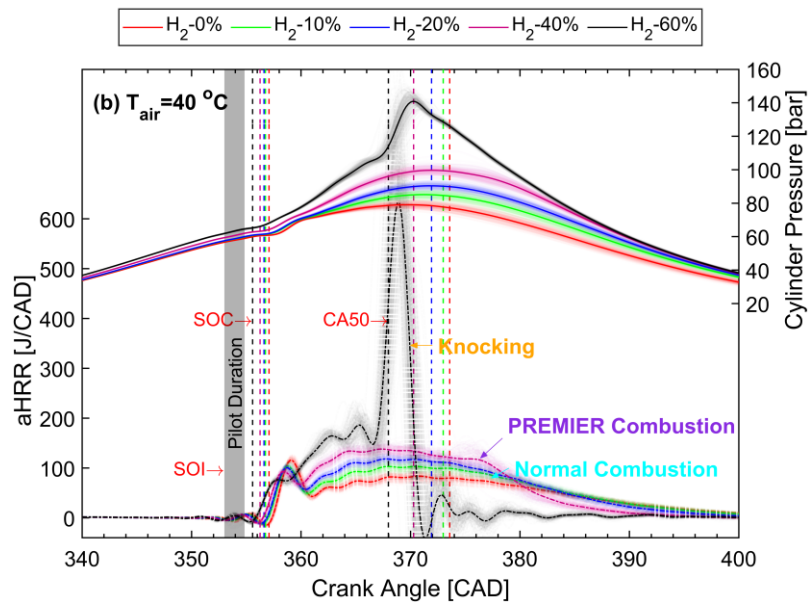
Table 3. Overview of the engine operating conditions

Item	Unit	Value
Engine speed	rpm	1200
SOI	CAD BTDC	7
Pilot injection duration	ms	0.256
$\dot{m}_{\text{air}}$	kg/h	80
Equivalence ratio	-	0.5
$\text{H}_2$ mole fraction	mole %	0, 10, 20, 40, 60
Charge-air temperature	°C	17, 25, 40, 55, 70
Pilot energy ratio	%	10
$\text{CH}_4$ energy ratio	%	90, 87.1, 83.7, 74.9, 61.9
$\text{H}_2$ energy ratio	%	0, 2.9, 6.3, 15.1, 28.1
Total energy	MJ/h	123, 127, 131, 133, 136



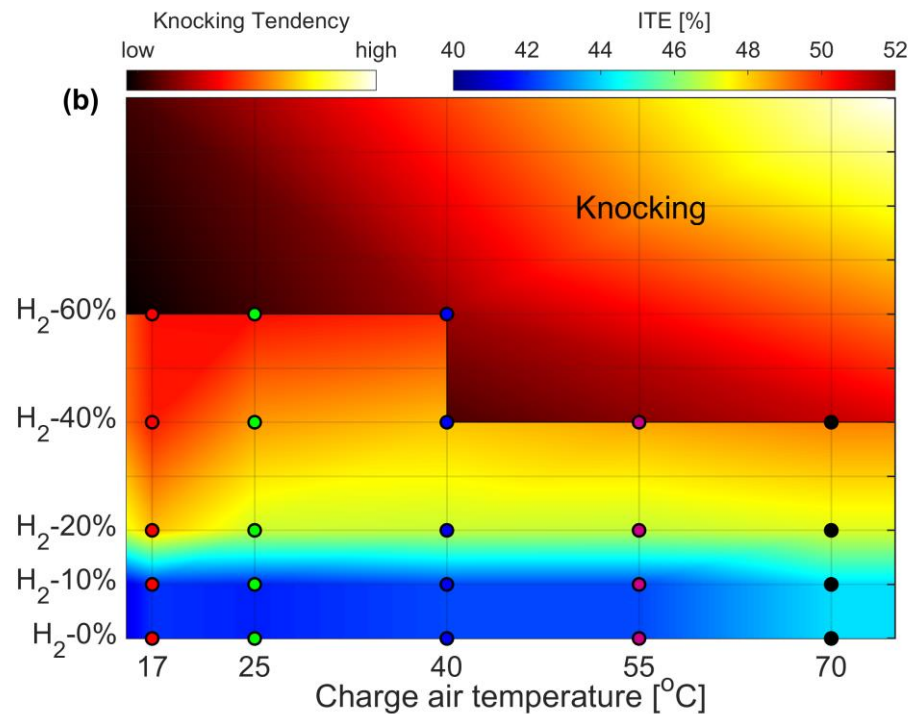
# Previous Results

- Tri-Fuel (TF) combustion



# Previous Results

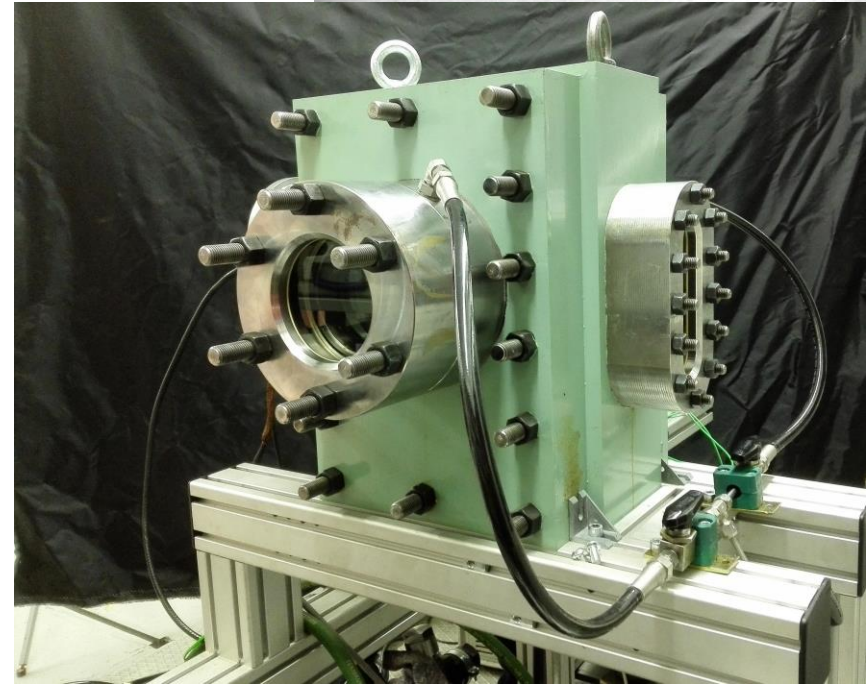
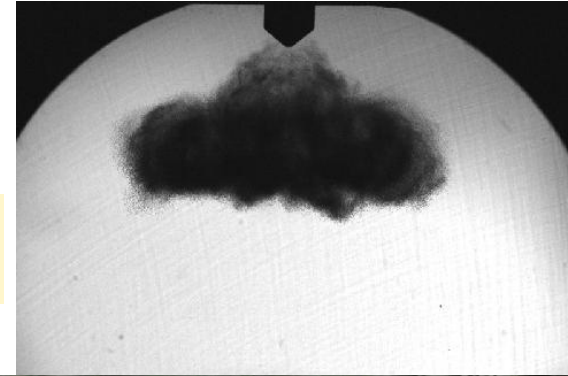
- Tri-Fuel (TF) combustion



# Present Cahema research

## Spray bomb

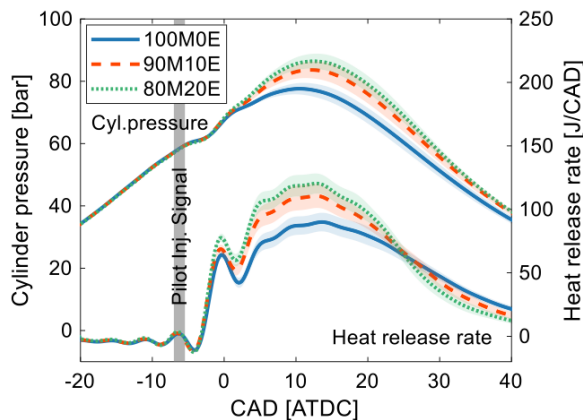
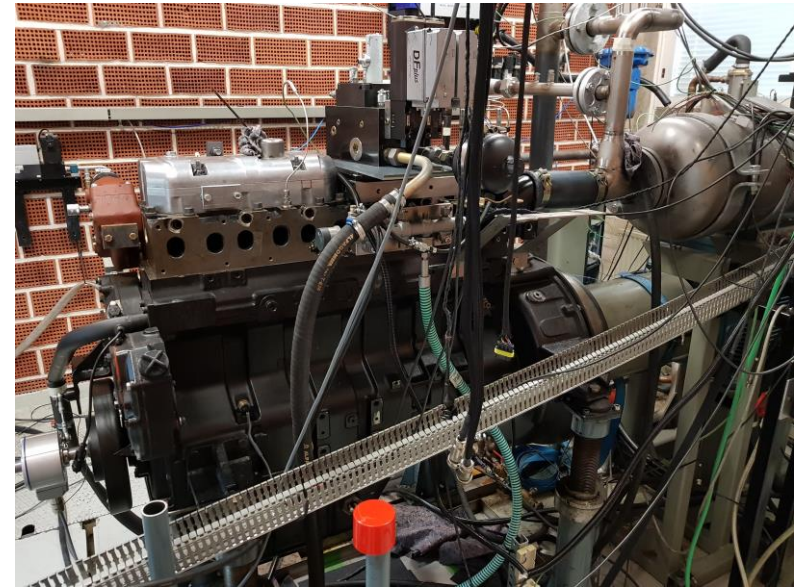
- Ammonia testing in the spray bomb
- Spray chamber
  - Non-reactive (N<sub>2</sub>)
  - max 115 [kg/m<sup>3</sup>]
  - 3 windows
- New: Methanol sprays (incl. drop sizes)



# Present Cahema research

## Single cylinder research engine

- Ammonia engine tests
  - Port fuel injection of ammonia/H<sub>2</sub>
- Ammonia + diesel pilot (DF)
- Ammonia + H<sub>2</sub> + diesel pilot (TF)
- Dual-fuel / Tri-Fuel / RCCI



(a)  $\omega=1500$  rpm and  $P_{PF}=1500$  bar

Table 1. Test engine specifications

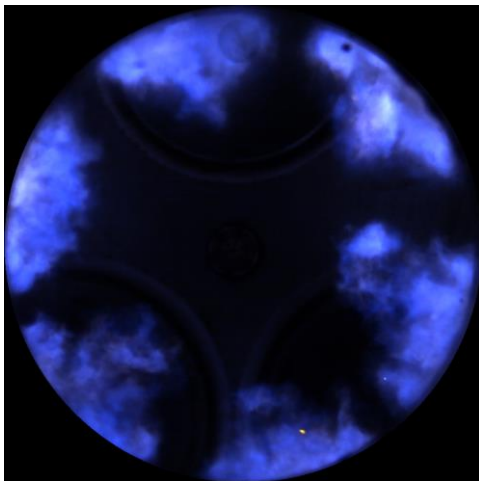
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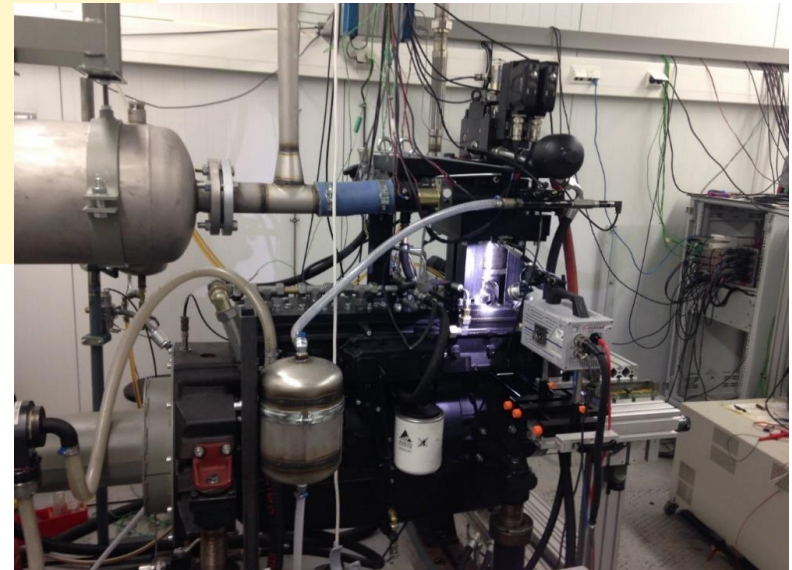
# Present Cahema research

## Optical engine

- Ammonia optical engine tests
  - Port fuel injection of ammonia/H<sub>2</sub>
- Ammonia + diesel pilot (DF)
- Ammonia + H<sub>2</sub> + diesel pilot (TF)
- Dual-fuel / Tri-Fuel / RCCI
















Optical TF combustion  
(CH<sub>4</sub>+H<sub>2</sub>+diesel)





# Present Cahema research

## Time table

	2021				2022				2023		
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3
WP1 Ammonia Rig											
WP2 RCCI											
WP3 Optical Engine											
Mobility and short visits											
Publications											
Milestones				M1 			M2 		M3		

**M1** Ammonia rig measurements done; **M2** Engine ready for RCCI ammonia-H<sub>2</sub> -diesel pilot study;  
**M3** Optical engine ready for ammonia-H<sub>2</sub> tests

Project duration 1.3.2021 – 28.2.2023