Effect of Ambient Temperature and Density on the Transition of Hot Temperature Combustion to Low Temperature Combustion Using Commercial Diesel and Waste Plastic Diesel in an Optical Access Machine

By

Mr Zin Thu Aung

PhD Sandwich Program(AUN/SEED-NET)

Energy Engineering

Advisor: Asst.Prof.Dr.Chinda Charoenphonphanich

Co-Advisor:Prof. Hidenori Kosaka

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Outlines of Presentation

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   ii. Literature Review
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2. Material and Methods
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Introduction

Background of Waste Plastic

- Plastics are essential materials due to their numerous applications in daily life. Consequently, a huge number of plastic products accumulate as waste in the environment.
- Plastic waste is a big issue in the world including Thailand, because the amount of recycled plastic remains low due to recycling problems.
- Thailand produces about 3.5 million tonnes of plastic waste, only 18% of which is recyclable

https://investforesight.com/russia-to-ban-single-use-plastic-items/

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https://investforesight.com/russia-to-ban-single-use-plastic-items/

- One of the recycling problems is economy as they need to be collected separately or sorted before the process can begin. Most plastics are not compatible with each other and hence they cannot be processed together during recycling.
- For instance, a polyvinyl chloride (PVC) bottle in polyethylene terephthalate (PET) recycle can ruin the entire batch by becoming yellowish and brittle.

Continued

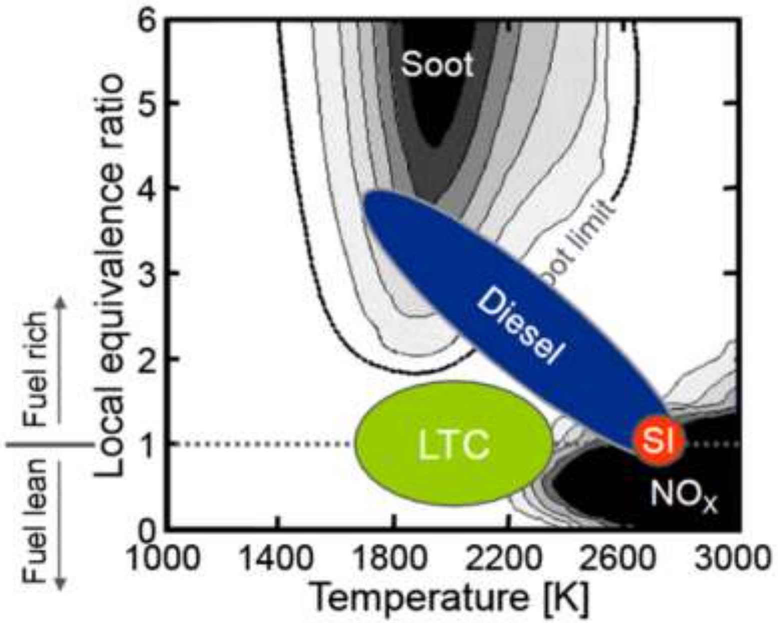
- Unlike recycling, pyrolysis does not require the separation of different plastics.
- The fast pyrolysis of mixed waste plastic into alternative fuels is an effective method for waste plastic management.

Pyrolysis

https://theconversation.com/if-we-cant-recycle-it-why-not-turn-our-waste-plastic-into-fuel-96128
https://www.thechemicalengineer.com/news/neste-aims-to-turn-plastic-waste-into-fuel/

Background of Diesel Engine

- Direct injection diesel engines are used extensively as the prime movers for public transportation, agricultural and heavy machinery, and electricity generation because they enable high efficiency and lower fuel costs .
- However, diesel engine emissions are a significant contributor to environmental pollution, especially NOx and smoke.
- Emissions from diesel engines have become more important due to the increasing strictness of emission regulations.



Φ-T map

https://www.greencarcongress.com/2011/05/ltc1-20110520.html

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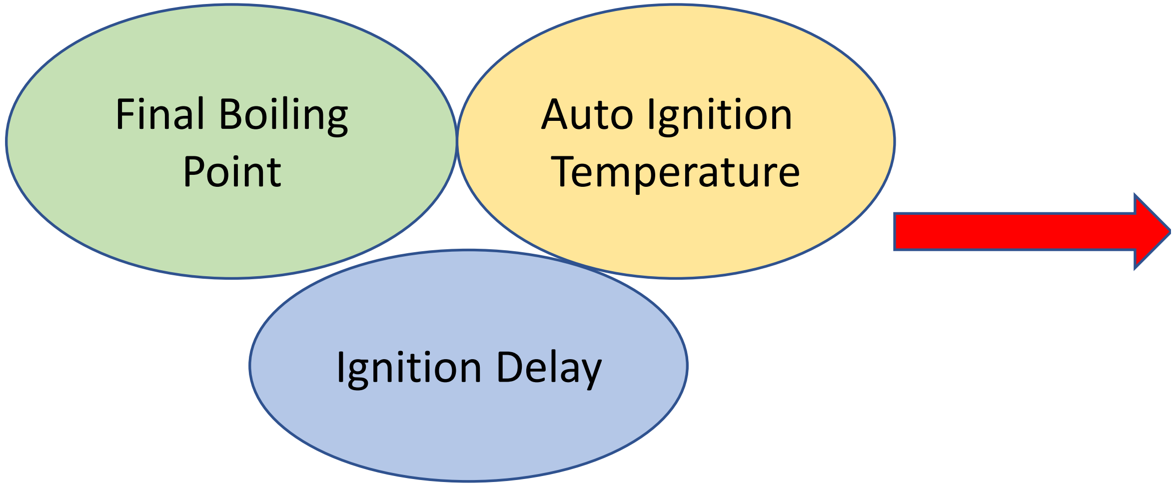
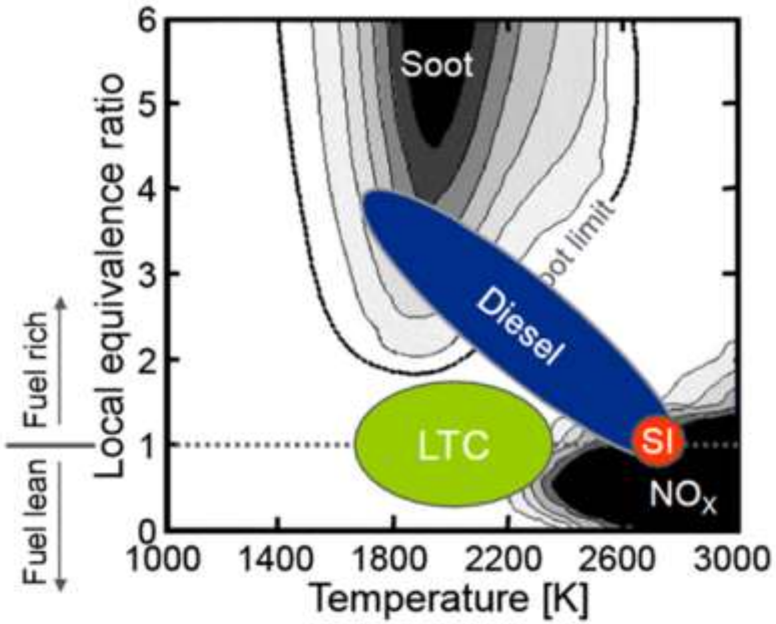
What is the Low Temperature Combustion?

- LTC in diesel engines is capable of avoiding NOx and PM formation zones.
- LTC is a general term for homogeneous charge compression ignition (HCCI), premixed charge compression ignition (PCCI), and reactivity control compression ignition (RCCI) combustion mode.

Premixed compression ignition (PCI) is a basic concept of LTC.





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ii. Literature Review

Conventional Combustion

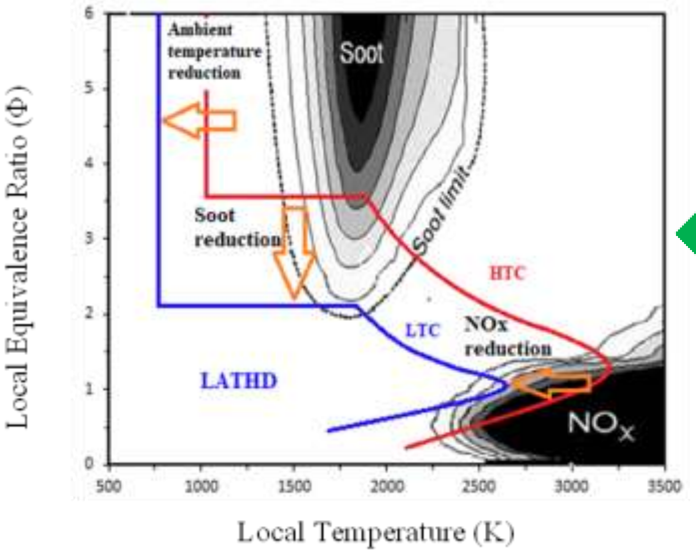
(Trade-off of NOx and Soot)

- **Injection Timing**
- **Injection pressure**

- **Heavy EGR**
- **Low Compression Ratio**
- **Low Cetane Fuels**

Low Temperature Diesel Combustion

(Trade-off of NOx and Soot & UHC and CO)



Low Ambient Temperature

&

High Density

iii. Statements of Research

- Motivation: The new emissions trade-off for LTC is NOx and Soot vs UHC and CO.
- Objective: The purpose of this research is to reduce NOx and soot without damaging fuel efficiency.
- Contribution: Propose to investigate the combustion characteristics under different temperature and density at constant pressure without EGR and low cetane fuels.

RQ: How is the combined effect of temperature and density on combustion characteristic to change from convectional combustion to low temperature combustion?

Materials and Methods

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Table 1. Physical properties and CHSO of test fuels

Property	**ASTM Method**	**CD**	**WPD**
Density@15°C (kg/m^3)	D4052	824	806
Viscosity@40°C (Cst)	D445	3.24	2.9
Cetane Index	D976	56.43	67.93
Energy Content (MJ/kg)	D240	45.86	46.29
Flash Point (C)	D93	52	40
Auto ignition Temp (˙C)	E-659	218	201
T_{10} (˙C)			
T_{50} (˙C)	D85	208	182
T_{90} (˙C) volume%	D85	288	291
	D85	352	385
Paraffin Content (wt. %)			
Total Aromatics Content (wt.%)	D3238	60.61	80.41
Sulfur Content (wt. %)	D3238	13.48	5.05
Carbon Content (wt. %)	D5453	0.003	0.014
Hydrogen Content (wt. %)	D5373	84.75	83.45
H/C Ratio	D5373	13.62	14.14
Ash Content (wt. %)	D189	1.93	2.03
	D482	0.001	0.001
Fatty acid methyl ester, %vol	EN14078	8.7	0
Copper strip corrosion	D130	1a	1a
Total Acid Number (mgKOH/g)	D664	0.27	0.26

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Table 2. Experimental conditions

Parameters	Values
Injection Pressure	140 MPa
Ambient Pressure	4 MPa
Ambient Temperature	1050K, 900K, 750K
Ambient Density	13.27, 15.49, 18.58 kg/m^3
Injected Amount	30 mg
Energizing Time	2.13 ms for CD 2.148 ms for WPD
Oxygen Concentration	21% (volume)
Temperature of Cylinder Wall, Inlet and Exhaust	453 K
Nozzle Diameter	0.2 mm (single hole)

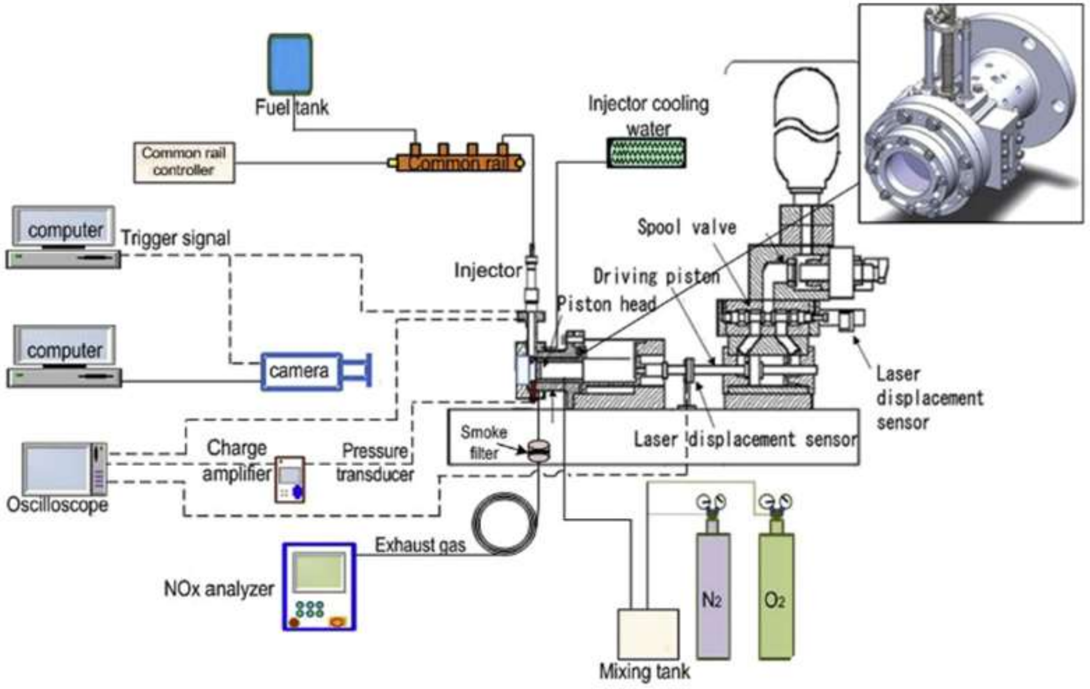
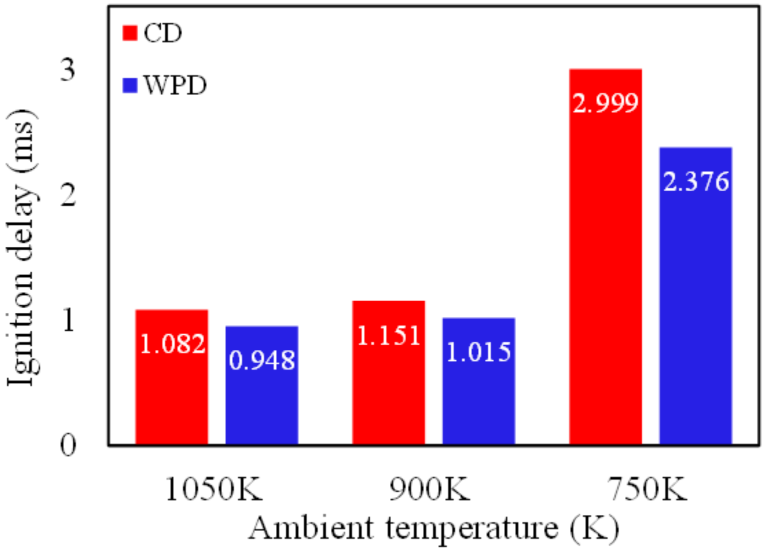
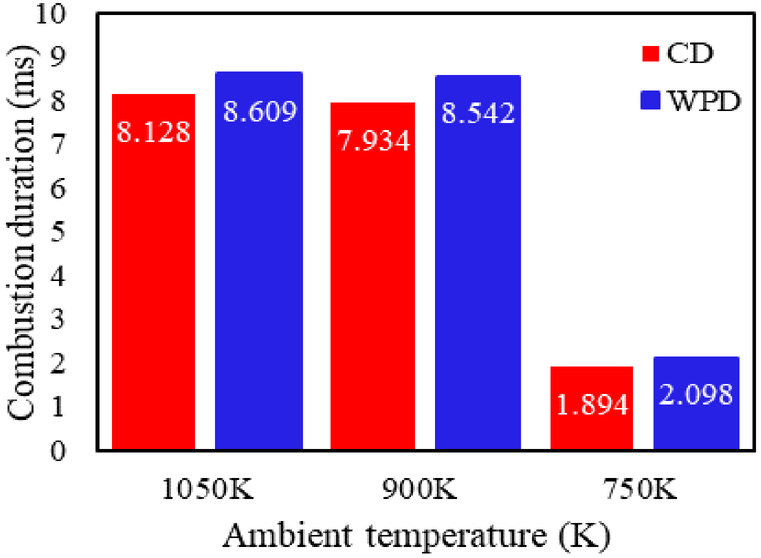


Fig. 2 Schematic diagram of experimental apparatus

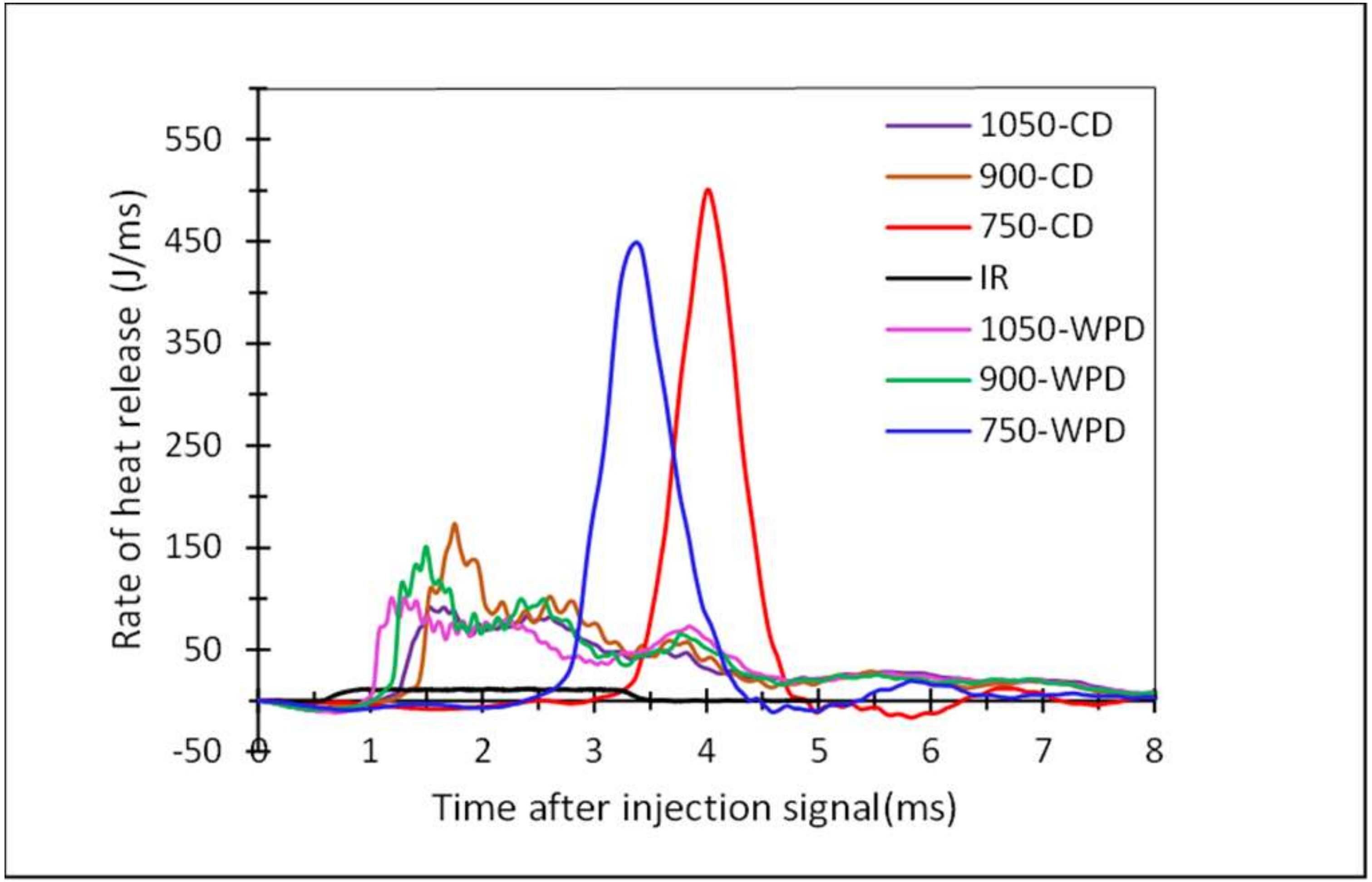
Results and Discussion

Ignition Delay and Combustion duration





Heat Release Rate (HRR)



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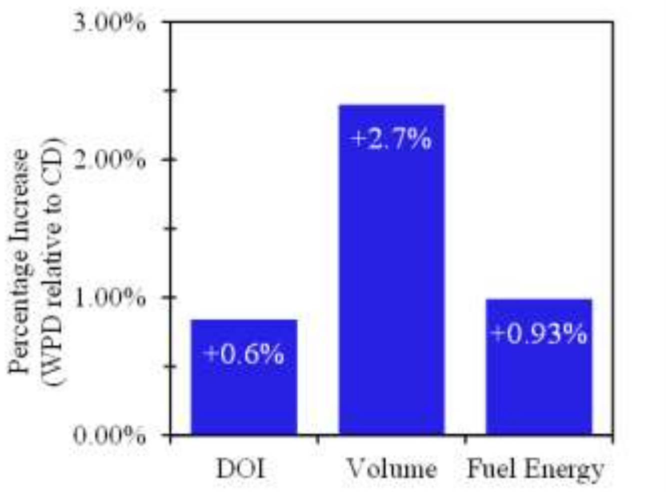
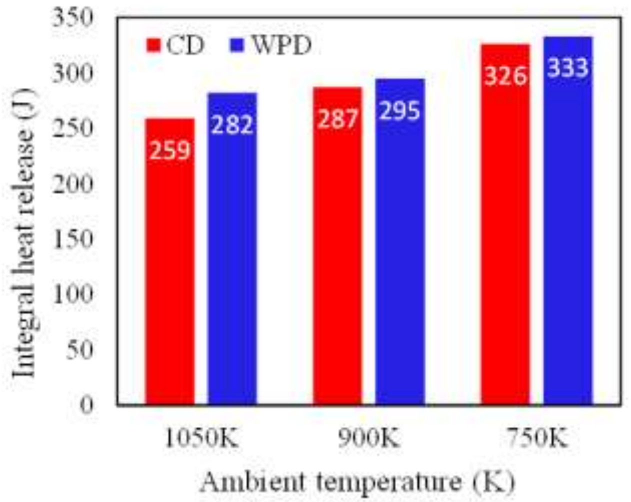
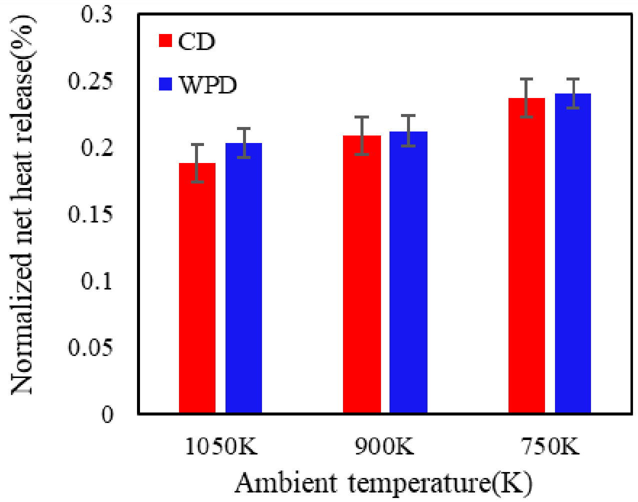
Integral Release Rate (IRR)

- Heat transfer loss is greatly reduced with low flame temperature and a short combustion duration.



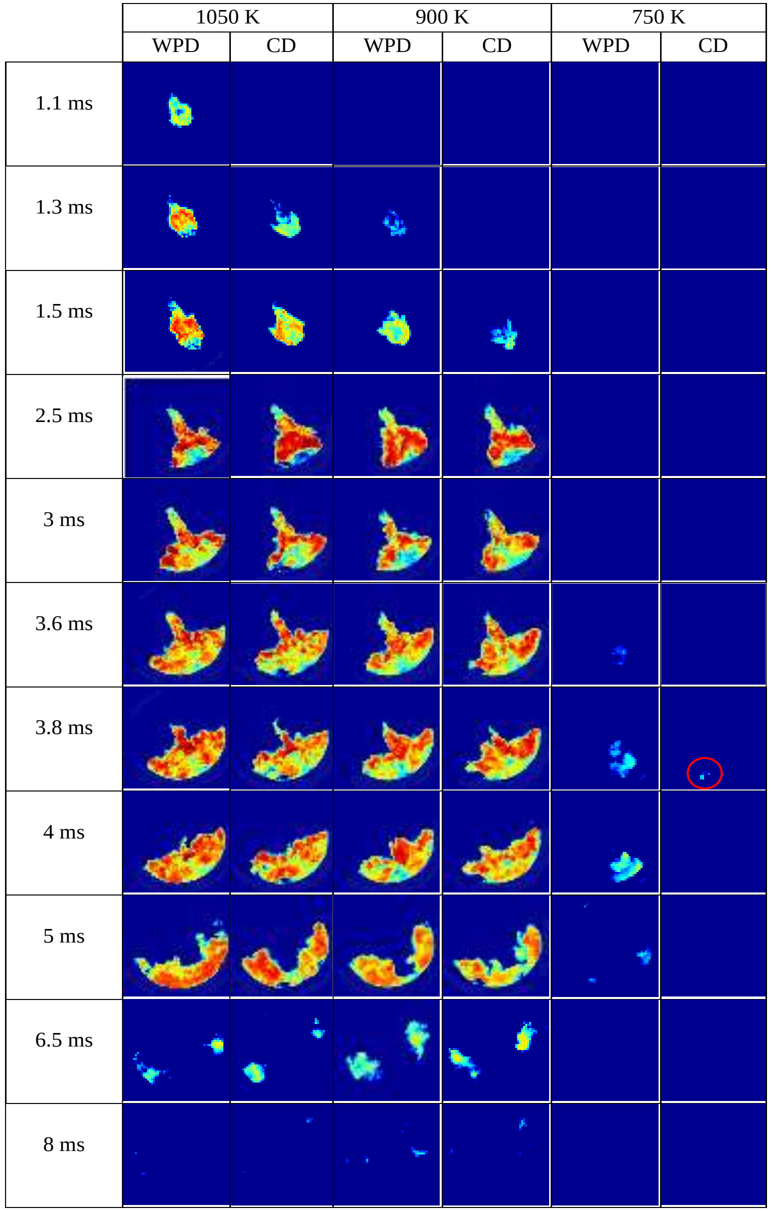




Spatial Distribution of Flame Temperature

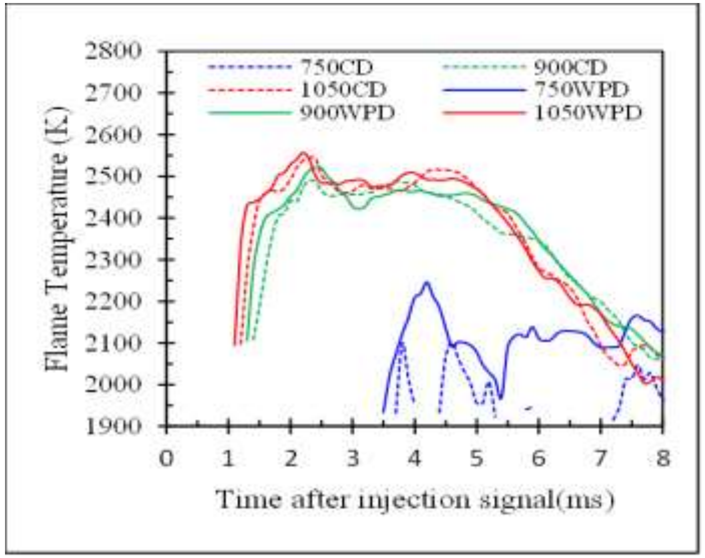
PV= mRT

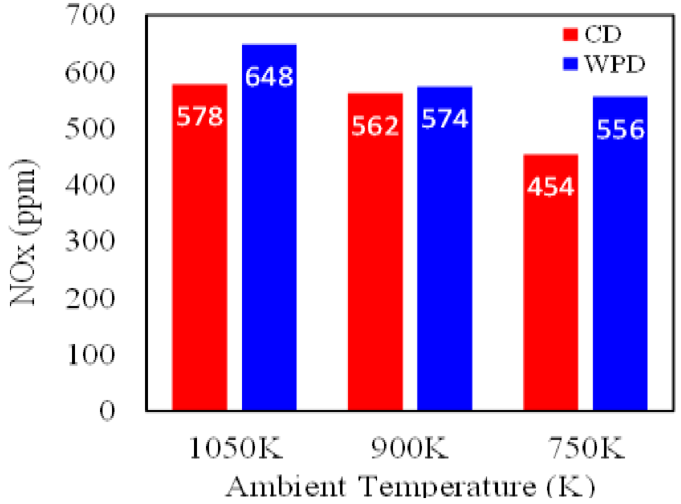
Q= mc(T_2-T_1)

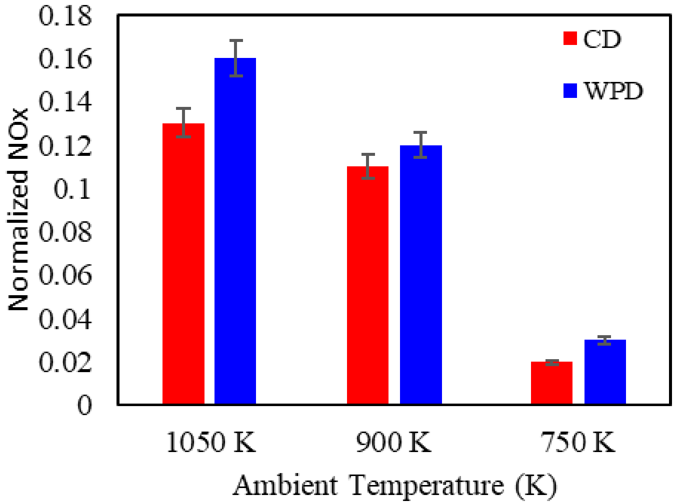


NOx Concentrations

- The NOx of WPD was higher than that of CD because of higher flame temperature, even though it had a short ID and lower peak HRR.
- Therefore, IHR is a dominant factor to interpret NOx and flame temperature.

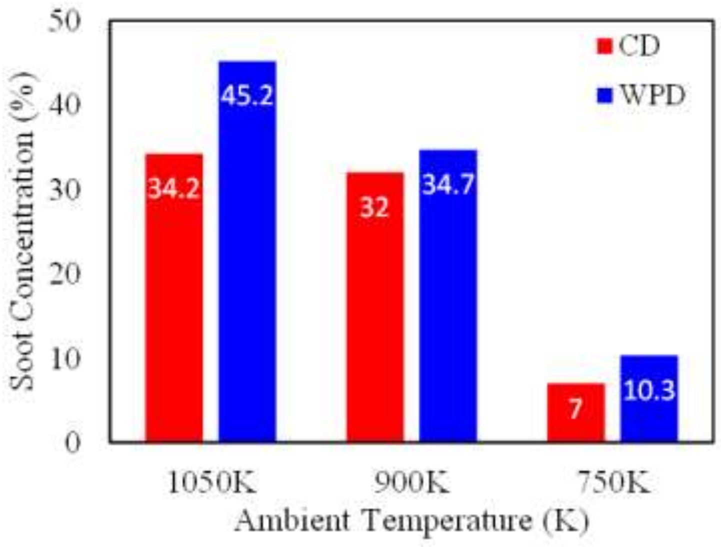


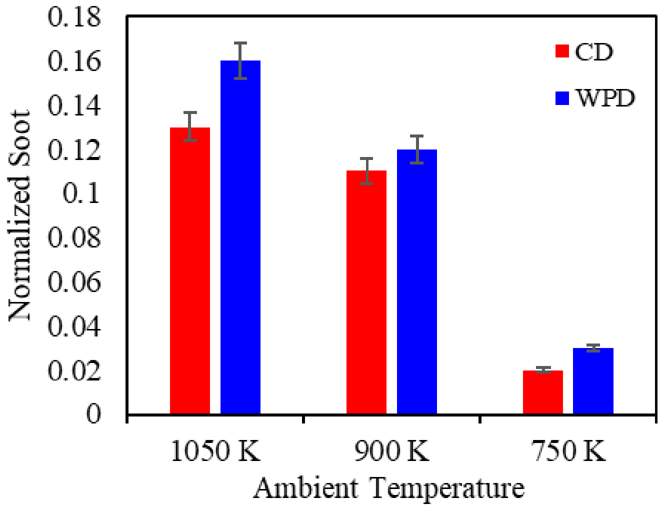




Soot Concentrations

- The degree of homogeneity and lean mixture formation of CD can be increased more than WPD because of a longer ID.
- Therefore, soot concentrations of WPD are higher than that of CD.





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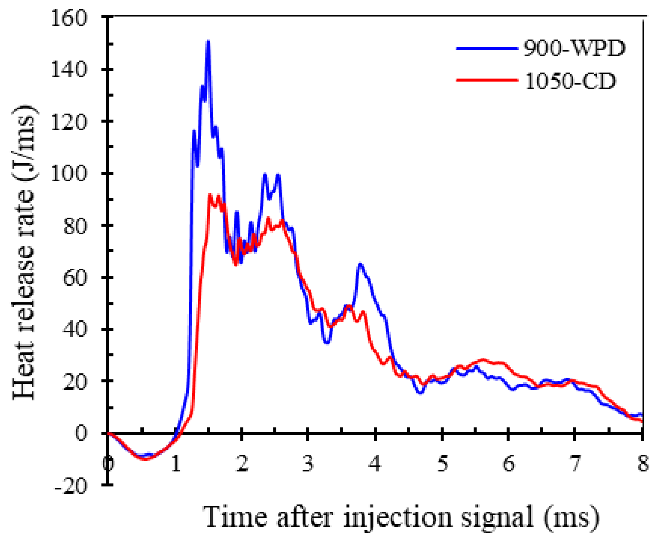
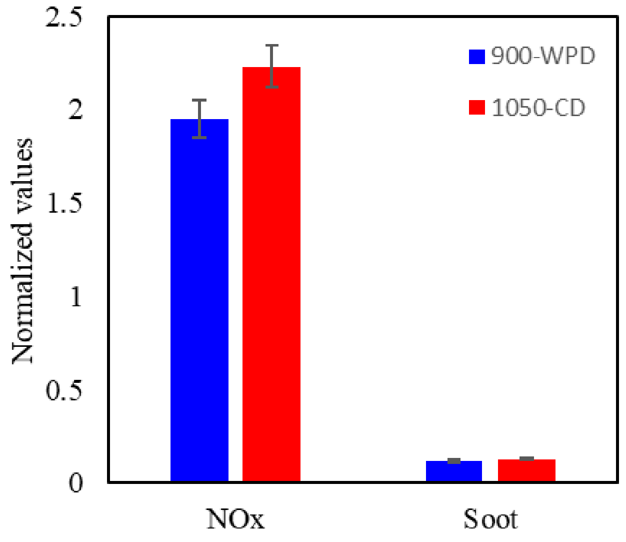
NOx and soot concentrations at the same ignition delay





- The soot formation tendency of low aromatic fuel is decreased at the same ID or cetane number.
- NOx formation is suppressed by the combined effect of low ambient temperature and high density.
- This information involves very important parameters for examining the optimum combustion phasing of different cetane fuels for real engine design.

Conclusions/ Summary

- Proposed a method of low temperature combustion without EGR and low cetane fuel.
- Effect of low ambient temperature and high density has been studied on low temperature combustion.
- NOx and soot can reduce simultaneously while improving combustion efficiency.
- Integral heat release is a dominant factor to interpret NOx emission.
- NOx and soot concentrations of waste plastic diesel are higher at same ambient condition.
- NOx and soot concentrations of waste plastic diesel are lower at same ignition delay.