

ECN5 – Diesel Combustion

SPRAY C/D EXPERIMENTAL SUMMARY

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PARTICIPANTS

PARTICIPANT	INSTITUTION
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- INTRODUCTION
- EXPERIMENTAL CONTRIBUTIONS
- IGNITION DELAY
- LIFT-OFF LENGTH
- TRANSIENT FLAME PENETRATION
- RADIAL WIDTH



- ECN4
 - Few experimental results from SC/SD
 - SNL/CMT



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ECN5 – Spray C/D



- Objective for ECN5
 - Improve the experimental database on Spray C/D
 - Combustion indicators
 - Spatially-resolved variables
- What has been done?
 - Experiments from CAT / CMT/ IFPEN / SNL
 - Main experimental diagnostic tool: high-speed OH* imaging (except from CMT)
 - Main results ID/LOL
 - Standardization of processing tools
 - The same routine has been applied to all institutions





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EXPERIMENTAL ARRANGEMENTS

• CAT





- CMT
 - High-speed Schlieren for ID
 - Low speed ICCD for LOL





EXPERIMENTAL ARRANGEMENTS

• IFPEN



- OH* chemiluminescence
- Filters: Semrock FF01-300/80-50 + Semrock FF01-315/15-50
- Lambert HiCatt S20 intensifier
- Cerco 45.5 mm f/1.8 lens
- Photron SAZ @ 75 kfps, 12.33 us exposure 9.42 pix/mm



• SANDIA





INVESTIGATED CONDITIONS

• Injector units

Institution	SC	SD
CAT/SNL	210037	209134
CMT	210003	209103
IFPEN	210003	209135

- Test matrices
 - Ref SA:
 - 15%02
 - 22.8 kg/m3
 - 900K
 - 1500 bar

	VALUE	SNL	CAT		IFPEN	CMT
			OH*	NL		
Т (К)	1200	C/D				
	1100	C/D			C/D	
	T4=1000	C/D		C/D	C/D	
	950	C/D		C/D		
	SA=900	C/D	C/D	C/D	C/D	
	850	C/D		С	C/D	
	T3=800			С		C/D
	750			С		
Pinj (bar)	12=500		C/D	C/D		
	11=1000		C/D	C/D		
	400	C/D			C/D	
rho kg/m3)	28.8					C/D



SOME EXAMPLES

• An example sequence from Spray C – IFPEN







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- Temperature sweep
 - Very similar results for CAT/SNL
 - IFPEN slightly shorter ID
 - Longer ID compared to SA





- Injection pressure sweep
 - Similar trends as for Tsweep
 - IFPEN results for SD show lower sensitivity to Pinj



ECN5 – Spray C/D



Uncertainty

- Similar scattering among institutions







IGNITION DELAY

• Spray C vs Spray D

- Similar results - No influence of Cav/NoCav on ID



ECN5 – Spray C/D





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- Temperature sweep
 - Very similar results for CAT/SNL/IFPEN
 - Slightly lower LOL for IFPEN at high T
 - Interaction betwen LL and LOL Challenge for combustion models





- Injection pressure sweep
 - Very similar results for CAT/SNL/IFPEN
 - Linear trend with injection \rightarrow LOL \propto u0^0.5
 - No difference trend with Pinj for SC and SD





- Spray C vs Spray D
 - Longer LOL for SD consistently with previous ECN4, SAE2016-01-0860







- Uncertainty
 - Processing issues with IFPEN highT data





- For CAT data, LOL is seen to increase around 3mm from the initial value
- IFPEN/SNL do not show this trend
- Longer transient period at low injection pressure





TRANSIENT LOL BEHAVIOUR

 A similar trend has been observed at ECN4 for CMT inert LL





- Constant pressure vs constant volumen vessel?
- Thermal effects
 - Gas scavenging among injection shots
 - Hot gases in the vicinity of the nozzle
 - Fuel residence time in the injector body before injection
 - Initial fuel is hotter than the late-injected one
 - Why are not the ID data stratified in the same way?

OPEN QUESTION





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 Based on the detected contours, a flame penetration can be defined as the maximum location where radiation is detected





- Nominal condition
 - Clear under-prediction by SNL
 - Similar results for CAT/IFPEN





Nominal condition

Consistent trends with inert spray



²⁹



- SA results (ECN3)
 - Flame penetration (from broadband) coincides with schlieren until steady phase
 - Acceleration occurs 500-600 us after ID







- Nominal condition
 - Consistent trends with inert spray
 - For the nominal condition, acceleration occurs too late to be visualized





- Temperature sweep
 - Acceleration process may still happen within observable limits for higher air temperatures



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- Probability map
 - Based on the detected shapes, a probability map is calculated over the quasi-steady period (2 to 3.5 ms ASOI)
 - The 50% probability
 level will be used for
 comparison of radial
 widths



 Results among institutions

ECN

- Similar results for SNL/IFPEN
- CAT wider flame



 Results among institutions

ECN

- Similar results for SNL/IFPEN
- CAT wider flame
- Results among injectors
 - SC shows slightly wider cross-section around LOL



 Results among institutions

ECN

- Similar results for SNL/IFPEN
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- Results among injectors
 - SC shows slightly wider cross-section around LOL







- Comparison among institutions has been performed
 - General agreement ID/LOL
 - Transient LOL behaviour in CAT vessel
 No clear explanation
- Initial findings (ECN4) in terms of injector comparison have been confirmed
 - No clear difference in ID
 - Longer LOL for SD for all operating conditions
 - Faster flame penetration for SD



- What's still to be done?
 - More detailed analysis of results, transient LOL?
 - Spatially detailed measurements
- CFD challenges
 - SA vs SC/SD trends
 - Interaction between LL and LOL at higher T/lower Pinj
 - Link between nozzle flow and LOL/ID trends



ANY QUESTIONS/COMMENTS?