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Study of In-Cylinder Combustion Phenomena by Simultaneous Dual-Direction In-Cylinder Direct Imaging in a Direct-Injection Hydrogen Engine for Motorcycles

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In order to achieve carbon neutrality in small mobility applications, hydrogen engines have attracted attention due to their fast combustion characteristics and wide flammability limits. However, detailed understanding of in-cylinder combustion phenomena in hydrogen engines remains limited, particularly from a spatial perspective.

In this study, a direct-injection hydrogen engine for motorcycles was investigated using a newly developed simultaneous dual-direction in-cylinder direct imaging method. Two optical access windows were arranged on the cylinder head, enabling simultaneous observation of flame propagation from both intake and exhaust valve directions. OH radical chemiluminescence imaging was applied to observe combustion processes.

OH chemiluminescence imaging was combined with combustion analysis, histogram-based image analysis, CFD analysis, and two-band near-infrared thermometry (Fig.1). These combined approaches enabled spatial evaluation of combustion phase and emission behavior from both qualitative and quantitative viewpoints. Furthermore, under high-speed operating conditions, dual-direction imaging captured changes in flame shape and flame propagation behavior, indicating rapid flame development in high-flow fields (Fig.2).

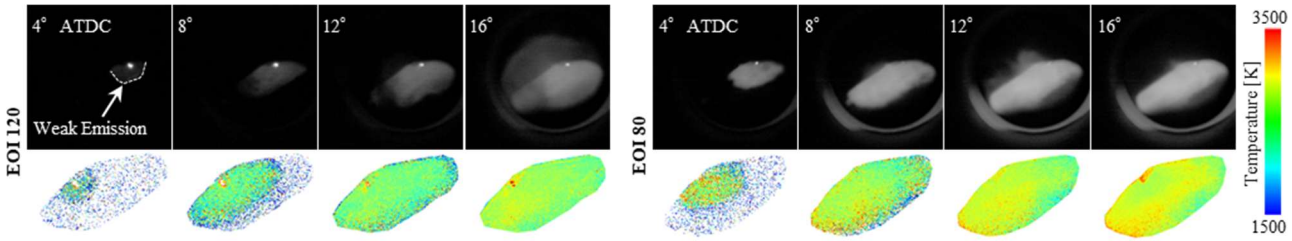
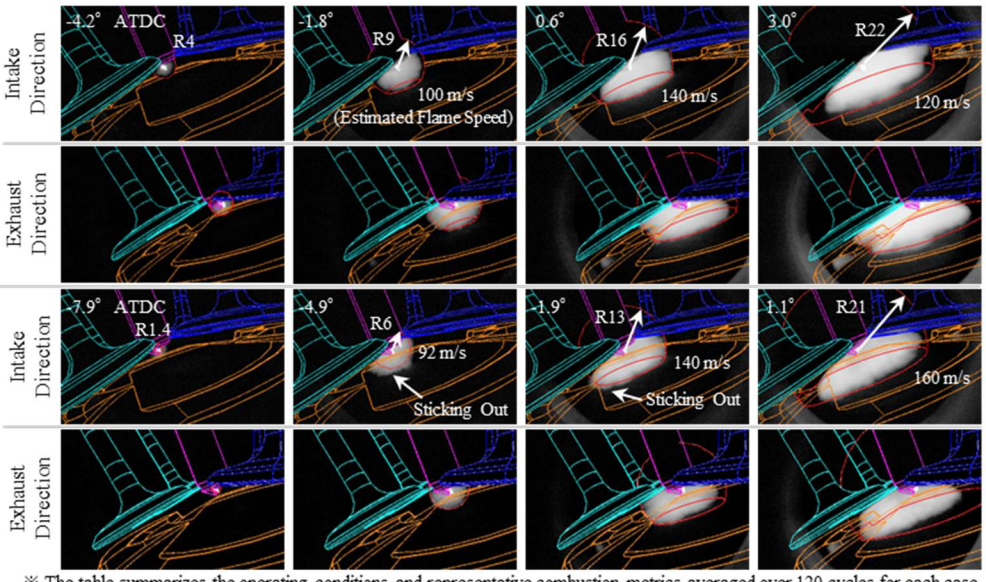


Fig.1 Dual-irection OH* and Two-Band Near-infrared Thermometry Combinated Imaging

Engine Speed [rpm]	8000
Throttle Opening	WOT
Excess Air Ratio	1.0
Fuel Pressure [MPa]	9
Ignition Timing [°ATDC]	-4
End Of Injection [°ATDC]	80
Pmax [kPa]	8946
IMEP [kPa]	1870
COV of IMEP [%]	0.96
Frame Rate [fps]	20000

Engine Speed [rpm]	10000
Throttle Opening	Partial
Excess Air Ratio	1.25
Fuel Pressure [MPa]	9
Ignition Timing [°ATDC]	-6
End Of Injection [°ATDC]	100
Pmax [kPa]	7445
IMEP [kPa]	1621
COV of IMEP [%]	0.84
Frame Rate [fps]	20000



※ The table summarizes the operating conditions and representative combustion metrics averaged over 120 cycles for each case.

Fig.2 Dual-Direction OH Chemiluminescence Images of In-Cylinder Combustion at High-speed Operating Condition