

Multi-Point Heat Flux Measurement and Evaluation of Abnormal Combustion Effects in Direct-Injection Hydrogen Motorcycle Engines

Shoki Mashiko¹⁾ Masakuni Oikawa²⁾ Yuji Mihara²⁾ Yuki Kaga¹⁾
Aoshi Yokomori¹⁾ Takumi Iwata³⁾ Hiroshi Kato⁴⁾ Kyohei Izumi⁴⁾
Kenichi Sano⁵⁾ Tomohiko Kamio⁶⁾ Yoshinari Ninomiya⁷⁾ Michiyasu Owashi³⁾

1) Graduate School of Tokyo City University, 1-28-1 Tamazutsumi Setagaya Tokyo, 158-8557, Japan
2) Tokyo City University Research Center for High Efficiency Hydrogen Engine and Engine Tribology (HEET), The same as above
3) MOTORA, Inc. 1-17-16-403 Sakado Takatsu-ku Kawasaki Kanagawa, 213-0012, Japan
4) Kawasaki Motor Co, Ltd., 1-1 Kawasaki-cho Akashi, Hyogo, 673-8666, Japan
5) Honda Motor Co., Ltd. 3-15-1 Sensui, Asaka, Saitama, 351-8555, Japan
6) YAMAHA MOTOR Co., Ltd., 2500 Shingai Iwata Shizuoka, 438-8501, Japan
7) SUZUKI MOTOR CORPORATION 300 Takatsuka Hamamatsu Shizuoka, 432-8065, Japan

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Hydrogen engines have attracted considerable attention as a promising carbon-neutral powertrain technology. Owing to their unique combustion characteristics, understanding local wall heat transfer and abnormal combustion behavior is essential for improving efficiency and durability. In this study, four thin-film heat flux sensors were installed in a direct-injection hydrogen motorcycle engine to investigate local heat transfer characteristics from 2000 to 10000 rpm. Furthermore, heat flux behavior during a pre-ignition event was successfully measured and evaluated.

Figure 1 shows the local heat-flux distributions measured at 2000 and 10000 rpm. At all sensor locations, the heat flux increased with engine speed. Higher heat-flux values were observed not only during combustion but also during the compression stroke, which may be attributed to enhanced convective heat transfer caused by stronger in-cylinder flow at higher engine speeds.

Figure 2 compares the surface temperature and heat-flux histories under normal combustion and pre-ignition conditions. At 10000 rpm and $\lambda = 1.7$, pre-ignition was observed. The corresponding cylinder pressure reached approximately 20 MPa before spark timing. The heat-flux rise appeared in the order of Intake Side, Front Side, Between-Bores Side, and Exhaust Side, indicating that pre-ignition originated near the intake side. The maximum heat flux reached approximately 60 MW/m² at the Front Side, nearly six times higher than that under normal combustion conditions.

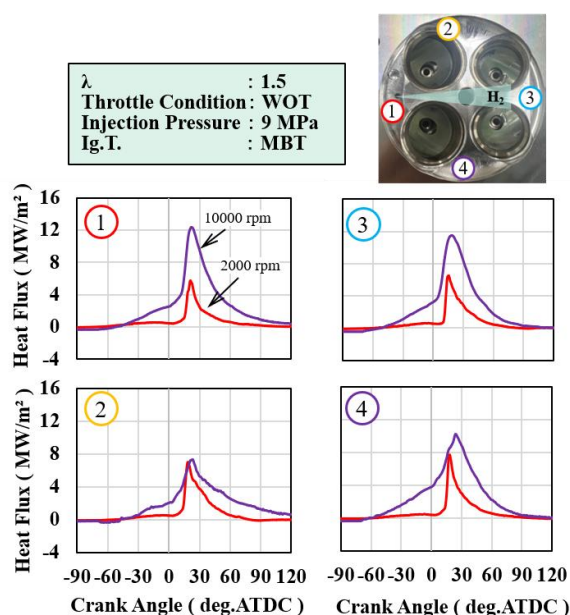


Fig. 1 Effect of Engine Speed on Local Heat Flux Distribution

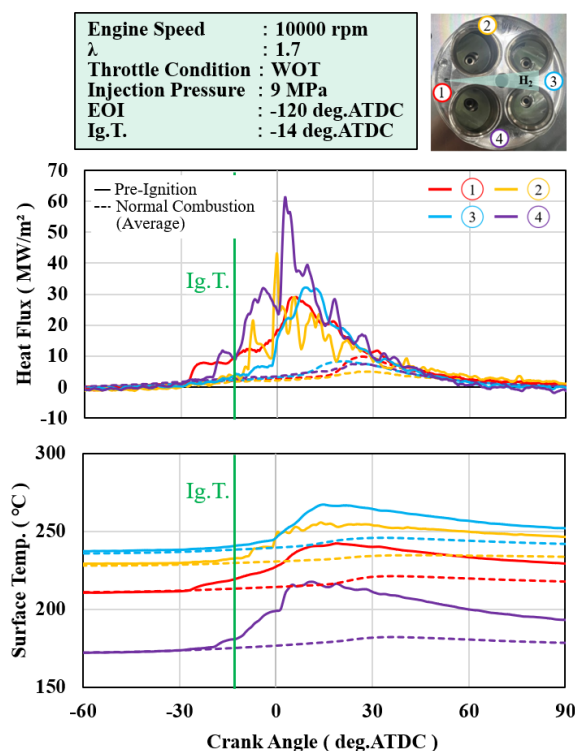


Fig. 2 Comparison of Surface Temperature and Heat Flux during Pre-Ignition and Normal Combustion