Application of thin film thermal sensor to IC engine

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Comprehensive research and development on the IC (internal combustion) engines has been conducted in the SIP, Cross-ministerial Strategic Innovation Promotion Program in Japan [1] for realizing maximum thermal efficiency of 50 %. A high-performance heat flux sensor is required to understand a mechanism and evaluate a mitigation method of heat loss on engine inner wall. The sensor needs the performance of fast response of 10 kHz, available heat flux range of 10 kW/m^2 to 10 MW/m^2 level, adjacent multi-point sensing for turbulent heat transfer study as well as heat and pressure resistance up to 250 degree C and 10 MPa. To meet these requirements, a fabrication method of thin film RTD on a metal substrate of similar material to the engines was developed. The sensor also should be of same shape as a previous pressure or thermal sensor to use an already-existing sensor port.

The sensor having the three thin film RTD thermometers on its end face of an aluminum alloy substrate has been developed as figure (b). The sensor is flush mount on the inner wall of a combustion chamber of the engine as figure (a). The local heat flux is measured by sensing wall temperature trend and analyzing 3D transient heat conduction inside the sensor. Through a heat flux measurement test, it is demonstrated that the developed sensor is applicable to the engines and takes clear wall surface temperature trends under a firing condition. Figure (c) shows phase-averaged local heat flux and overall pressure trends measured in the test engine with varying equivalent ratio. The lean burn condition is one of the mitigation methods of the heat loss of the gasoline engine, and this it is confirmed that the lean burn condition can reduce the heat loss during the combustion process. Instantaneous heat flux data also shows fluctuating heat transfer due to the turbulence. Details are present in the seminar.

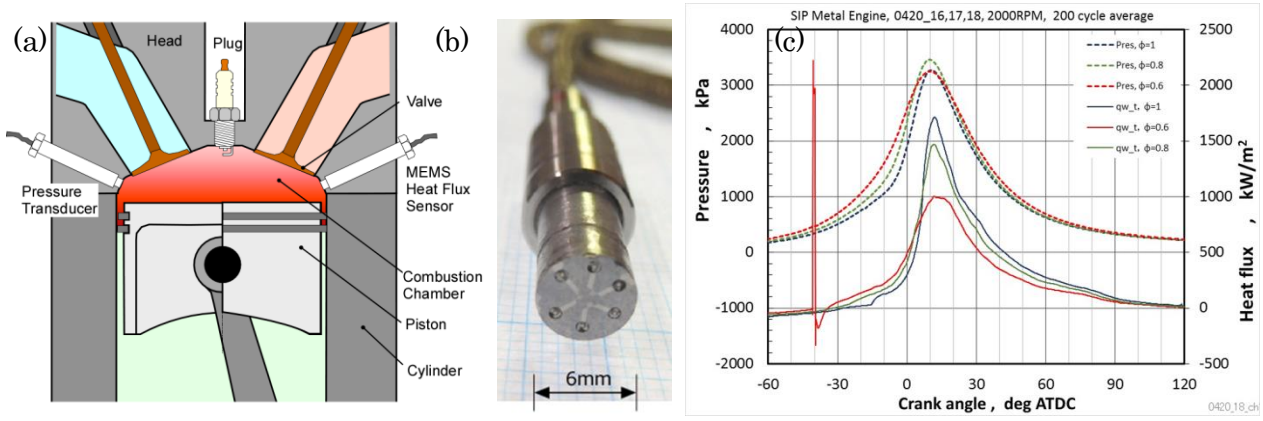

Figure: (a) Schema of heat flux sensor in IC engine. (b) Developed thin film heat flux sensor which has three thin film RTD on its end face. (c) Wall heat flux and pressure trends averaged over 200 cycles for the different equivalence ratio condition at 2000 RPM.

[1] Cabinet office, Government of Japan, Cross-ministerial Strategic Innovation Promotion Program (SIP), (online) available from <http://www8.cao.go.jp/cstp/gaiyo/sip/index.html>.
[2] Nakabeppu,O., Tsuchiya, T., Nakamura Y. and Nagasaka, K., "Thin film resistance sensor for wall heat flux measurement in premixed combustion", Trans. of JSME Vol.82, No.840, 2016, (in Japanese).
[3] Nakabeppu, O., Nagasaka, K., Nakamura, Y., Tsuchiya, T., and Dejima, K., "Thin Film Sensor on Metal Substrate for Measuring Heat Flux of Engine Inner Wall", Proc. 27th International Symposium on Transport Phenomena, ISTP-091, 2016