APPLICATION NOTE

IDENTIFICATION OF LOCAL VELOCITIES DURING INTAKE AND COMPRESSION

OFT sensor temperature waveforms provide engine signatures which can be related to the events occurring within the cylinder. The rate of cooling of the sensor can be used to identify regions of high and low velocity during intake and compression. Three examples are presented in this application note. The measurements were conducted in two production automotive engines; the engine conditions are listed below:

	Chassis Dynamometer Tests	Engine Dynamometer Tests
Sensor Locations	0.75 in. from cylinder wall near spark plug 0.25 in. from cylinder wall near exhaust valve	0.375 in. from cylinder wall near intake valve
Engine	General Motors 3.78 liter, V6, 8:1 C/R, calibrated	Chrysler 2.5 liter, 4 cyl. 8.5:1 fuel injected
Torque	15 ft.lbs	30 ft.lbs
RPM	1800 RPM	1600 RPM
Vacuum	-12 in. Hg	Unk
Timing	-23 deg. BTDC	Unk
Dwell	27 deg.	Unk

Two distinctive shapes of the sensor temperature waveforms are shown in Figures 1 and 2. Near the cylinder wall at the exhaust valve, the sensor is continually cooled until the flame front arrives at the sensor. In contrast, the sensor located 0.75 in. from the cylinder wall near the spark plug is initially cooled but gradually warms up prior to the arrival of the flame front. During intake and compression, the sensor temperature is over 1000°F higher than the cylinder gas temperature. Therefore, the sensor can only be cooled by the cylinder gases during this part of the engine cycle; the minimum cooling occurs when the velocity approaches zero. In fact, the sensor surface is heated from the interior of the sensor. Thermal waves persist throughout the sensor and in this part of the engine cycle, the interior elements are warmer than the sensor surface and supply heat to the sensor surface. The OFT signal originates at the thin film on the sensor surface.

The local gas velocities during intake and compression can be computed with EAS 100 heat transfer software. [1,2] The results of an example analysis of the sensor temperature waveform measured near an intake valve are shown in Figure 3. At this location, the sensor is abruptly cooled when the intake valve is opened. The heat flow from the cylinder gases to the sensor is shown in Figure 3a; corresponding estimated local cylinder gas velocities are shown in Figure 3b. The assumptions required to estimate the cylinder gas velocity are described in separate application notes. [1,2] Notice that at this location, the heat flow and velocity approach zero just prior to ignition. The OFT provides a hot film anemometric measurement with approximately 0.1 ft/sec resolution during intake and compression. This high resolution is due to the high over temperature of the sensor and the extraordinary signal-to-noise ratio of the technology. When the temperature of the sensor does not equal the gas temperature and the heat flow to the sensor approaches zero, the local cylinder gas must also approach zero within the resolution of the measurement. [1,2]

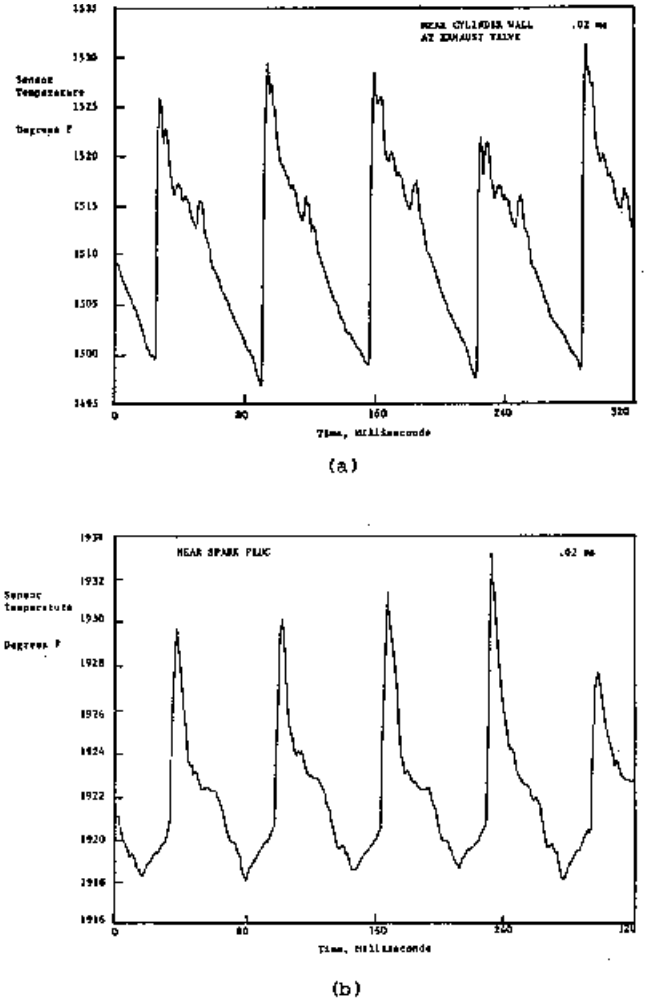

Figure 1. Multiple Engine Cycle Sensor Temperature Waveforms. 3.78 Liter, V6, 8:1 C/R, carburated General Motors engine; 15 ft.lbs torque, 1800 RPM. a) 0.25 in. from cylinder wall at exhaust valve; b) 0.75 in. from cylinder wall near spark plug.

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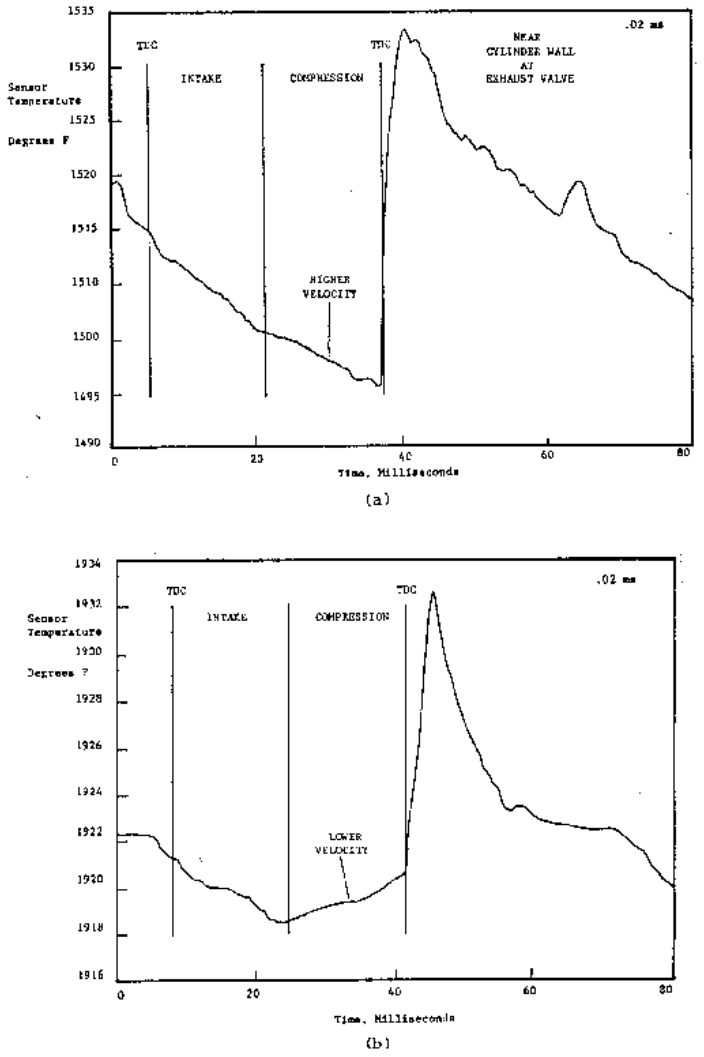

Figure 2. Single Engine Cycle Sensor Temperature Waveforms. 3.78 liter, V6, 8:1 C/R, Carburated General Motors Engine; 15 Ft. Lbs Torque, 1800 RPM. a) 0.25 in from Cylinder Wall at Exhaust Valve; b) 0.75 in.l from Cylinder Wall Near Spark Plug.

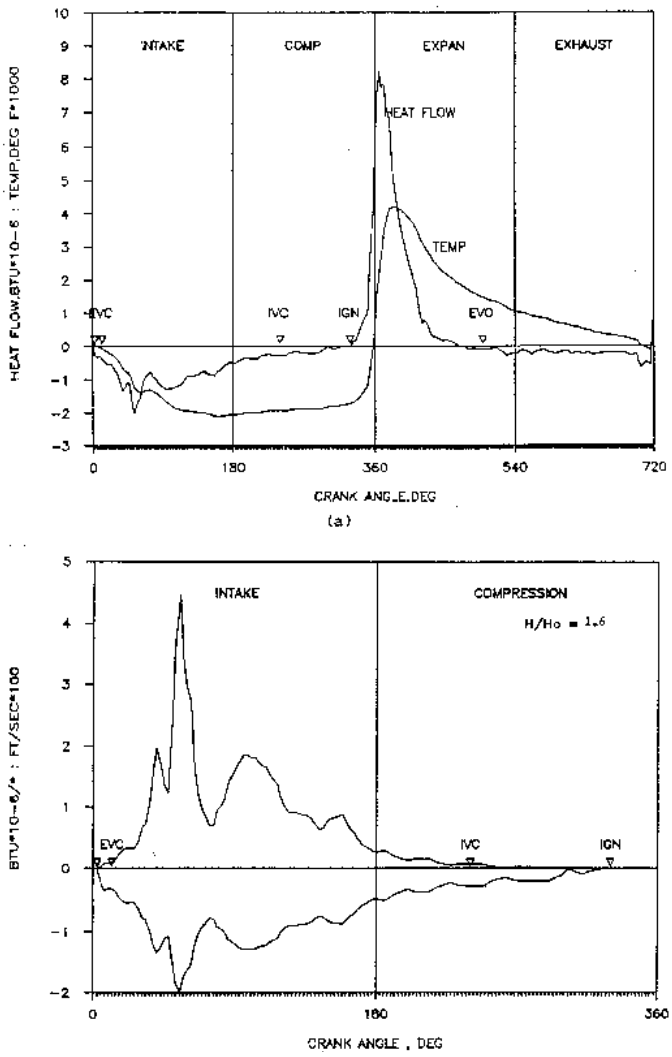

Figure 3. OFT Waveforms Measured Near Intake Vale. 4 Cylinder, 8.5:1 C/R Fule Injected Chrysler Engine; ~ 30 Ft. Lbs. Torque, 1600 RPM, Sensor Located 0.375 in. from Cylinder Wall. A) Sensor Temperature and Heat Flow; b) Heat Flow and Cylinder Gas Velocity.

The results shown in Figures 1 through 3 are typical of those measured in several contemporary production engines. Generally, the gas swirls into the cylinder with initially higher velocities near the center of the cylinder. As the gases are compressed and continue to swirl, the velocities near the cylinder wall become higher than those measured near the center and eventually the cylinder gases near the center approach zero just prior to ignition. Additional data is now being reduced to map out the velocities across a cylinder as a function of crank angle and will be available in the near future. Please contact the Accufiber factory for further details on methods of measuring cylinder gas velocities during intake and compression.

1. An Introduction to EAS 100 Heat Transfer Analyses", Application Note EAS100-A2, 1988.

2. R.R. Dils and M.P. Moore, "Optical Fiber Thermometer Measurements in Automotive Engines," Presented at ISA 86, Houston, Texas; October 13, 1986, p. 1159.