APPLICATION NOTE

ACCELERATION OF COLD CYLINDER GASES INFRONT OF A PROPAGATING FLAME FRONT

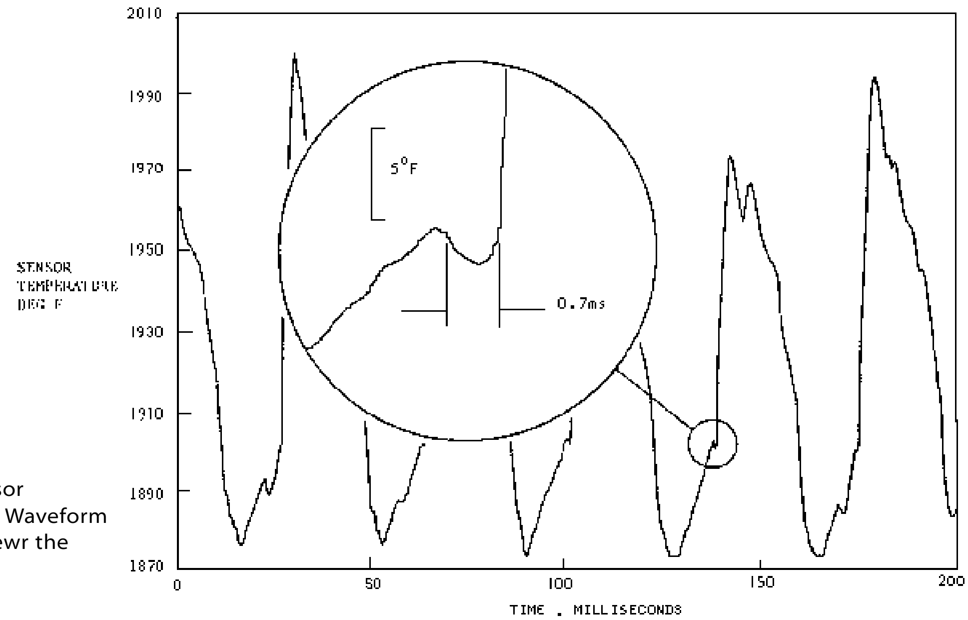

Figure 1: Sensor Temperature Waveform Measured Newr the Spark Plug

As a flame front propagates across the cylinder, unburned gases in front of the flame are compressed and accelerated by the expansion of the burning gases. The acceleration of the cold gases in front of the propagating flame front has been anticipated and described by the models of the combustion processes in the cylinder for several years. The OFT provides the first actual measurement of this phenomenon in an internal combustion engine.

Cylinder gases are heated only a few hundred degrees during intake and compression. While the OFT sensor is cooled only a few tens of degrees from an average temperature near 1600°F during the same period. Therefore, during this part of the engine cycle, the sensor acts as a hot film anemometer with a large overtemperature (>1000°F). When the gases accelerated in front of the propagating flame arrive at the sensor, the sensor is abruptly cooled as shown in Figures 1 and 2.

The abrupt cooling just in front of the flame front is measured throughout the cylinder, but the flame fronts are quite complex and the phenomenon is not observed in every cycle. The flame propagation velocity is approximately 60 ft/sec. The width of the layer of accelerated gases is approximately 0.5 in and does not appear to be a strong function of the local average cylinder gas velocity.

This measurement provides an excellent demonstration of the temperature and time resolution of the Accufiber OFT technology,. In the expanded portion of the sensor temperature waveform measured near the spark plug, it can be seen that the analog noise is less than the digitizer resolution. The digitizer resolution was 0.035°F for these experimental conditions; the signal-to-noise ratio (S/N) was approximately 55,000/1. The analog resolution, defined as the RMS value of the random noise within the 0-10KHz bandwidth, was approximately 0.0046°F, which corresponds to a S/N ratio of approximately 350,000/1. OFT analog S/N ratios are a function of the average sensor temperature, but in general, the analog noise will be equal or less than the resolution of a 12 bit digitizer. This high signal-to-noise ratio permits compensation of the OFT signal to 10KHz

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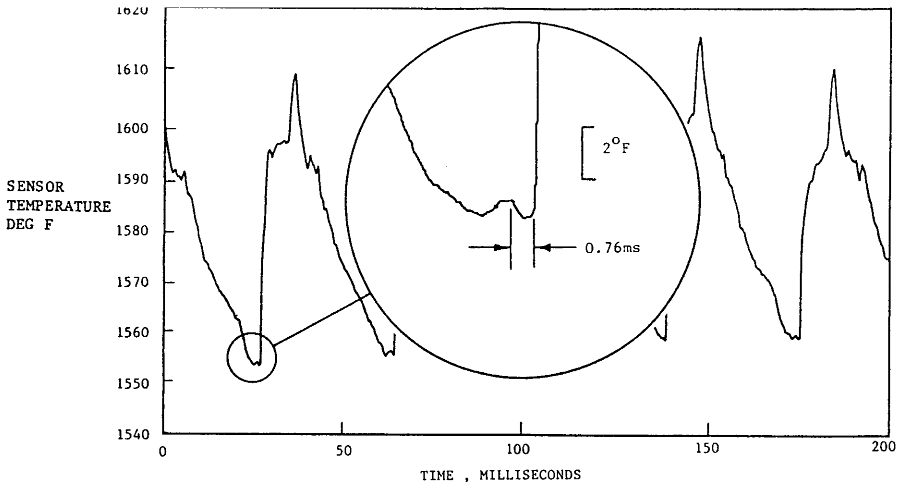

Engine Conditions:

3.78 Liter, 6 Cyl., 8:1 C/R General Motors engine
3100 RPM, 84 MPH, 86 ft.lb torque
-10″ Hg vacuum, -15°BTDC timing 48° dwell

Measurement Conditions:

Near Spark Plug
Near Exhaust Valve

0.050″ dia. 2/1 L/D Blackbody Sensor
0.050″ dia 2/1 L/D Blackbody Sensor

12 bit digitizer 0.05 ms Δt
12 bit digitizer 0.05 ms Δt

±4V full scale
±2V full scale

107 gain, 0-10KHz bandwidth
108 gain, 0-10KHz bandwidth

Differential Mode, T_{ave} = 1911°F, 18.25°F/Volt
Diff. Mode, T_{ave} = 1562°F, 27.0°F/Volt