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Computer tomography of infra-red absorption and its application to internal-combustion engines

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ABSTRACT

A comparatively inexpensive instrument has been developed for the measurement of local concentrations of gaseous fuel and evaluated in terms of its application to the flow in the cylinders of internal-combustion engines. It is based on the absorption of infra-red light by hydrocarbons and computer tomography to provide spatially local information. This paper describes the instrument and its application to the flow in simple arrangements intended to represent the cylinders of an internal-combustion engine with provision for optical access.

The optical system is comprised a helium-neon laser, a lead-selenium sensor, a chopper, an amplifier and a microcomputer. It can readily be modified to improve spatial resolution by monitoring the temporal fluctuations in the intensity of the laser beam, the error from which was reduced to less than 0.8% in the present experiment. A translation and rotation scanning method formed the basis for tomography and the spatial distribution of gaseous fuel was reconstructed by the convolution method with the filter function of Shepp and Rogan .

The instrument was applied to a simulation of the flow in a lean-burn gasoline engine, the cylinder of which was made of quartz glass for the measurement. The methane fuel was injected at the intake valve or 100 mm upstream of the valve to simulate evaporated fuel with steady airflow, and the port geometry provided swirl corresponding to the ratios of 1.3 and 2.9. The cylindrical cylinder surrounding the quartz glass implied that the fibre which detected the laser light absorption at local positions along the light path were located after calculation of the true position within the flow.

Distributions of the concentration of methane are presented in figure 1, corresponding to the higher ratio of swirling flow and plane 70 mm from the cylinder head with the fuel injected close to the valve. The laser beam was passed by the optical fiber at 5 mm spatial intervals and to angles, corresponding to 5 degrees for rotation in the plane. The measurement region encompassed the total area of each plane apart from that within 1.5 mm of the wall. The fuel-rich region with the swirl port spreads in the clockwise direction with the swirling flow.

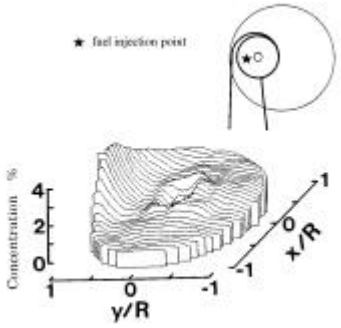

Fig.1 Fuel concentration of the swirl port with fuel injected at the intake valve (z=70mm).