SHIMADZU
Excellence in Science

Application News

No.V22

High-Speed Video Camera

High-Speed Imaging of Fuel Injection in Automotive Engines

Introduction

An important observational method. As an example, gasoline being injected from the injector and adhering to the cylinder walls is considered to be a cause of fine particles with a diameter of 2.5 micrometers or smaller (PM2.5), harmful particles contained in exhaust gas. In addition, ensuring that the gasoline is refined and homogenized during injection is important in regards to improving fuel efficiency.
This article introduces images of fuel injection by an injector, and the collision of the injected spray against a wall surface, obtained using the HPV-X2 high-speed video camera.

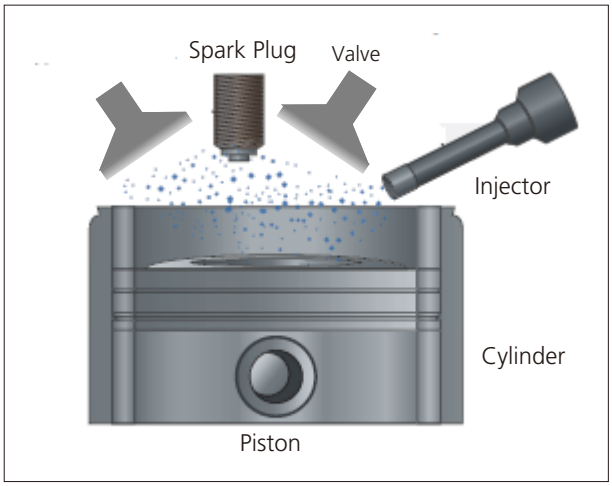


Fig. 1 Structure of an Automotive Engine

Measurement System

The HPV-X2 high-speed video camera was used in this experiment. Table 1 shows the instruments used. Instead of using a real engine, the experiment was performed with an injector placed on top and a flat plate below.

Table 1 Experimental equipment

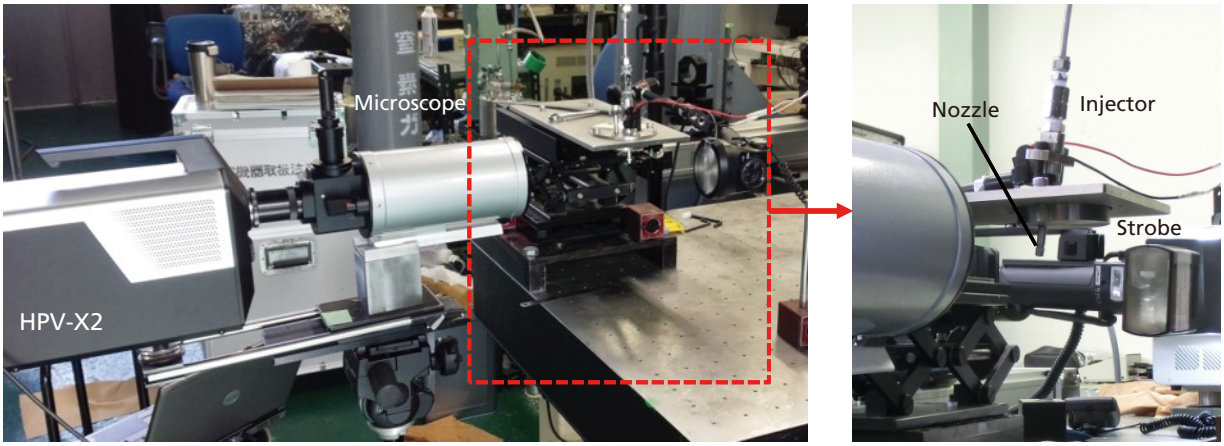
High-Speed Video Camera	: HPV-X2
Microscope	: Long Range type
Light Source	: Strobe Light

Results

Fig. 2 shows the test configuration. Figs. 3 to 6 show images obtained. Images were recorded in proximity to the nozzle outlet, as well as 1 mm, 2 mm, and 4 mm below the nozzle. It is evident that the fuel collected in proximity to the nozzle disperses as it travels downwards.
The fuel injected from the nozzle ultimately collides with the cylinder wall. Fig. 7 shows how the fuel collides with the cylinder wall. Image (2) in Fig. 7 clearly shows the collision of a droplet approximately 40 µm in diameter with the wall. Among the droplets produced after the collision, a droplet as small as 10 µm in diameter could be confirmed as indicated by the arrow in image (9).

Table 2 Imaging Conditions

Frame Rate: 10M frame/sec (Injection)
2M frame/sec (Collision)



Overall Setup (left); Around the Nozzle (right)

Fig. 2 Test Configuration

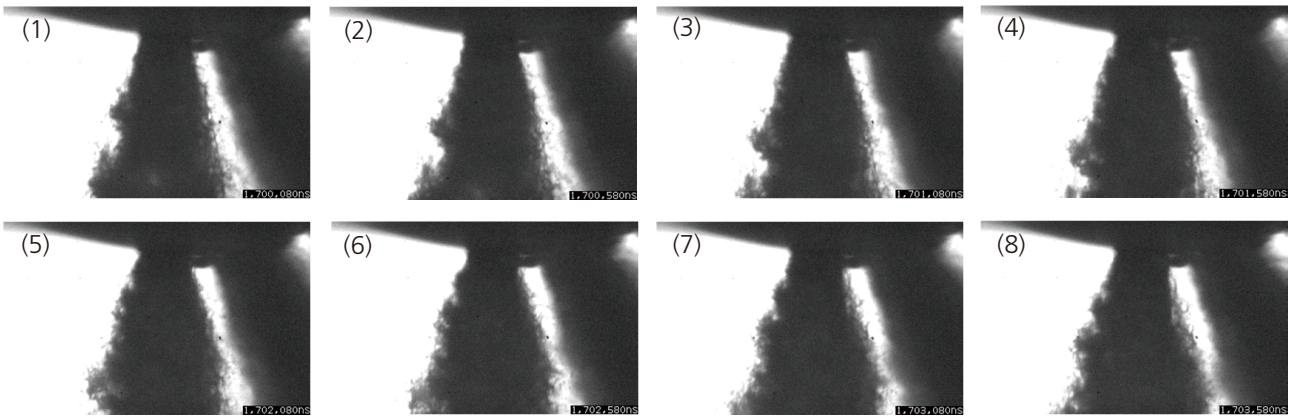


Fig. 3 Proximity to the Nozzle Outlet (500 nsec between images)

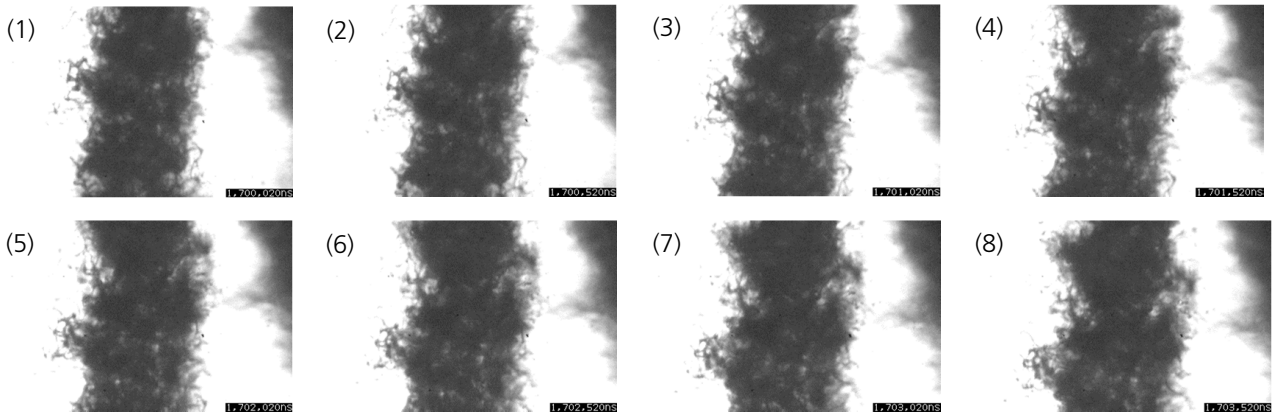


Fig. 4 1 mm Below the Nozzle (500 nsec between images)

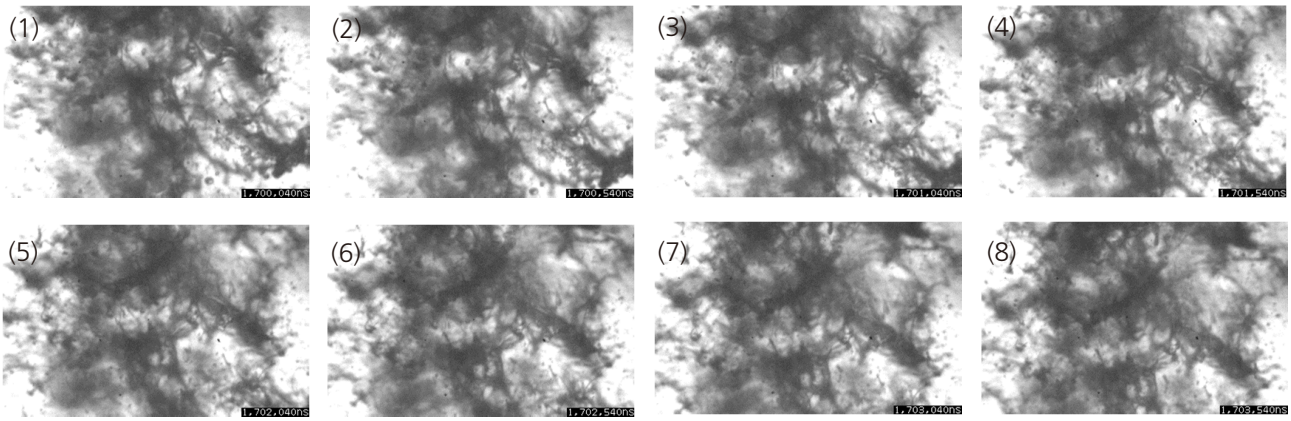


Fig. 5 2 mm Below the Nozzle (500 nsec between images)

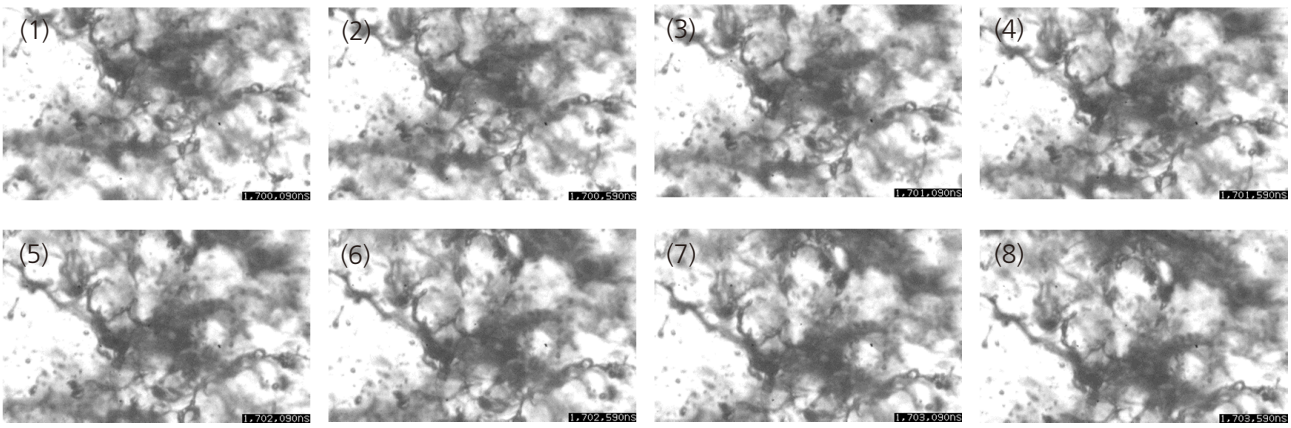
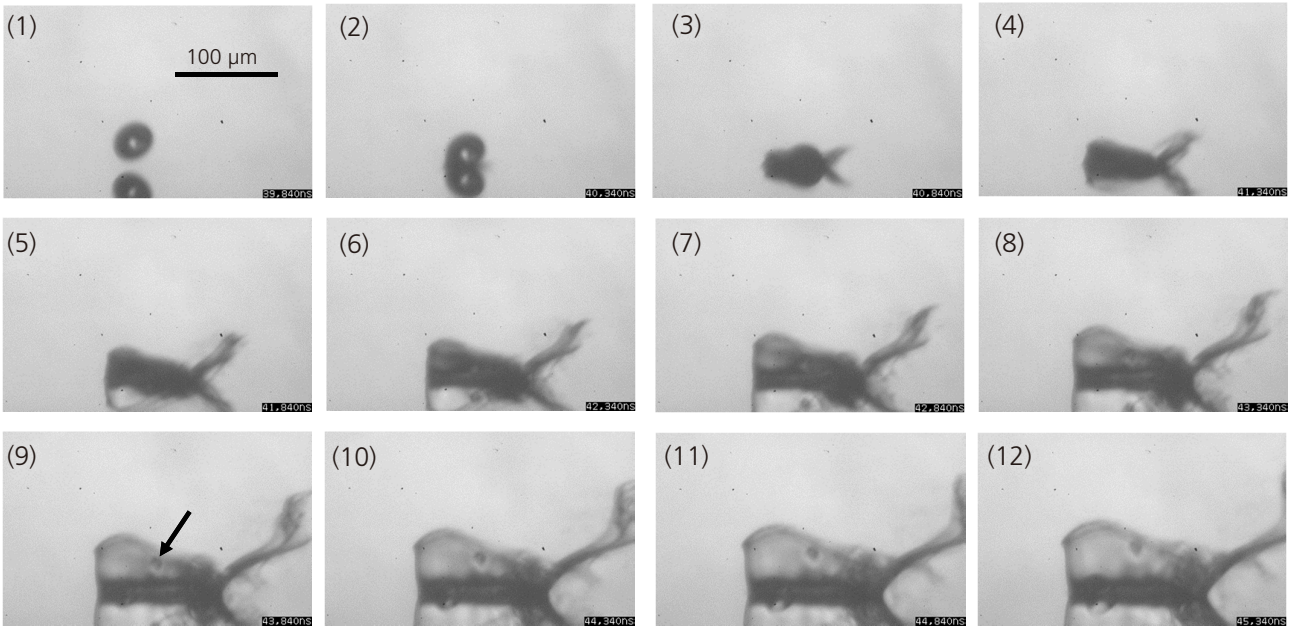


Fig. 6 4 mm Below the Nozzle (500 nsec between images)



Data provided by: Professor Kawahara, Okayama University

Fig. 7 Collision with the Wall (500 nsec between images)

Conclusion

Images of fuel injection by an injector, and the collision of the injection spray against a wall surface were taken using the HPV-X2 high-speed video camera. The speed of injection from the injector is very fast, and may reach 140 m/sec depending on the injection pressure. As a result, a recording speed of at least 10 Mfps is required to observe such a high speed phenomenon with a microscope. With the conventional model (HPV-X), clear images were not obtained due to insufficient sensitivity.

The HPV-X2 has at least six times the sensitivity of the HPV-X however, so the fine structure of the injection spray and the quality of the liquid are captured even through a microscope. The collision of the injection spray with the wall is also clearly recorded, and the size of the scattered particles can be measured using image processing software. The use of the HPV-X2 in this way can thus serve a role in the development of automobile engine injectors.

First Edition: Jul. 2015

Shimadzu Corporation
www.shimadzu.com/an/