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Application of New Photochromism Visualization Technique for Oil Transport Process around Engine Piston

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The authors have developed a new visualization technique based on photochromism for investigating the transport process of lubricating oil film around the engine piston. From the systematic experiments, it was confirmed that this technique can be used to examine the flow and the movement of an oil film on an engine piston and to investigate the dominant route of oil consumption in IC engines. Furthermore, this technique can give clear answers to the questions whether the oil films between the piston and the cylinder liner is connected or unconnected, and which side of the oil film is thicker.

Keywords: laser diagnostics, flow visualization, oil film, photochromism

1. Introduction

Elucidation of the oil transport phenomena around the engine piston and the mechanism of oil consumption is required for a further reduction of friction loss without the associated oil consumption in IC engines. To investigate this topic, the authors have developed a new visualization technique based on photochromism which can be used to directly examine the flow and the movement of an oil film on a piston [1][2].

2. Visualization System and Experimental Apparatus

Photochromism is a light-induced reversible change of color based on a chemical reaction. Illuminating a UV light to the arbitrary spot of oil film on a piston makes a marker of relatively long life which allows to observe the movement of oil film directly.
The optical measurement system is composed of a Nd-YAG laser as the UV light source, LED flashing lights for capturing images, and a high-speed camera with image-splitting optics to obtain the simultaneous two color images.
The color density was quantified by the absorbance calculated from the images of two timings, i.e., before and after coloring, and two colors where color darkening is almost negligible level and the greatest amount of darkening is observed [3]. The value of absorbance *As* obtained this method is linearly proportional to the oil film thickness.
The optical engine used in the experiments was a single-cylinder 4-stroke engine in mortared operation. The photochromic dye dissolved in the oil was spiropyran.

3. Results and Discussion

The left of Fig. 1 shows a schematic diagram of the piston. The imaging area of the piston surface is indicated by the red frame.

In this abstract, a typical example that the laser light sheet of the 3rd harmonic of Nd:YAG laser was illuminated at the lower part of the top land of piston with the throttle closed condition are introduced. Figure 1 shows the temporal variation of the 2D absorbance distribution from 90° after the top dead center (ATDC) to 100° ATDC of the intake stroke with the two degrees interval. The laser was shot at 88° ATDC of the intake stroke. From these images, it is made clear that the oil film thickness on the cylinder liner is few μm, that of the top land is around 20 μm and the majority of the oil film on the top land is unconnected to the oil film on the cylinder liner. Furthermore, the stretching motion of the connected oil can be found in the images.
In the full paper, the method of visualization system, the experimental results showing the oil film movement on the other lands and the piston skirt surface will be introduced.

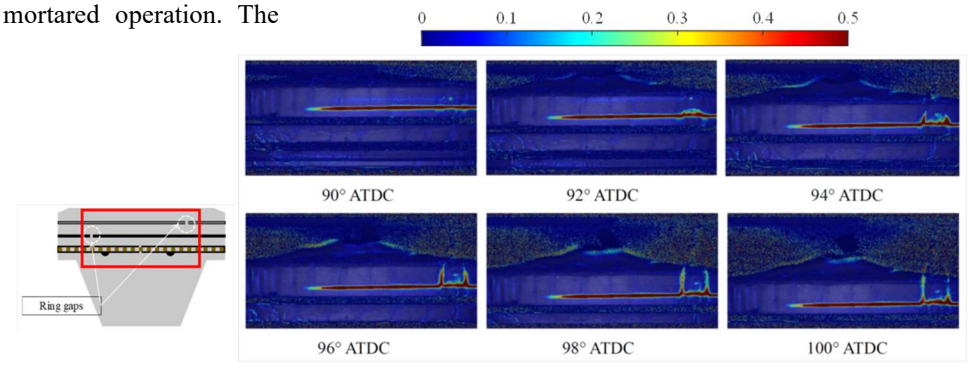

Figure 1: Temporal variation of 2D absorbance distribution in the intake stroke

4. References

[1] Azetsu, A., et al., "Development of a new visualization technique using photochromism for transport process of lubricating oil around the engine piston", Int. J. of Engine Research, 20, 7, 2019, 777-787.
[2] K. Kuratsuji, et al., "Measurement of Oil Behavior around Piston Using Photochromic Visualization Technique", Trans. JSAE, 50-1, 20194031, 2019, 55-60 (Japanese)
[3] Azetsu, A. et al., "Fluid Measurement Method, Fluid Measurement Device, and Measurement System" PCT/JP2018/ 019417,2018. .