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Aerodynamic drag reduction using a coating material in flapping wing

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Motive argument of our technical support

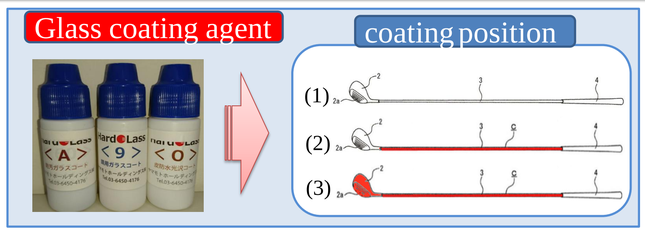
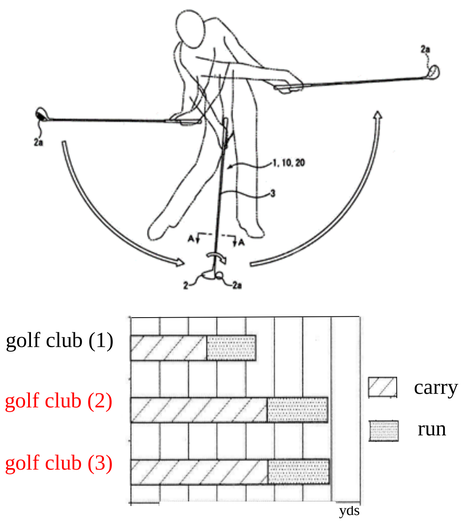


Table.1 Chemical composition of the coating materials used (mass%)

type	composition1	composition2
HardoLass O	polysilazane compound (90%)	
HardoLass 9	polysilazane compound (40%)	
HardoLass A	Perhydropolysilazane (3%)	dibutyl ether (53%)



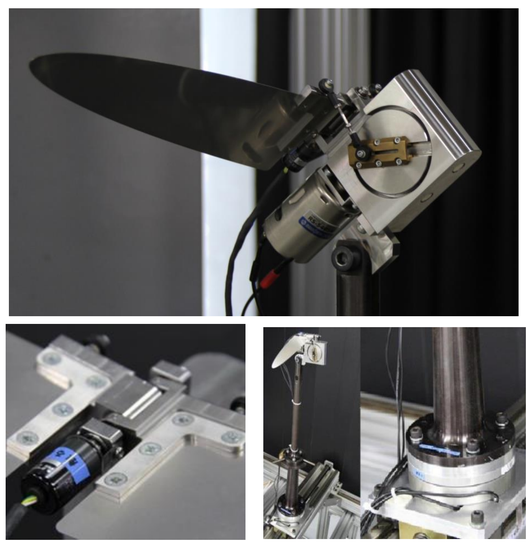
As a result of applying water-shedding coating to the golf club experimentally, as the flying distance measurement, we judged that there was a possibility of the drag reduction.

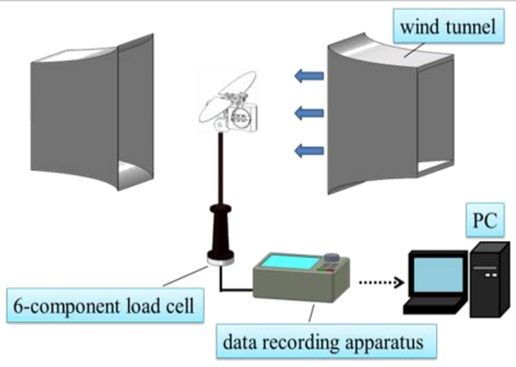
Our Research Motivation

1. Enhance the aerodynamic characteristics of the flapping wing depending on a water-shedding coating material consisting primary of SiO_2.
2. Clarify the optimum chemical composition in the coating material and the application thickness.
3. Investigate the relation between the separated vortex behaviors and the surface structure near the upper surface of the wing.

Get a new insight on aerodynamical effect of the coating material for air flow.

Experimental Apparatus





- Flapping Amplitude
  0 degrees to 60 degrees
- Flapping Frequency 0Hz to 10Hz
- Rotary Encoder for detect a Flapping Angle

Specification of the Elliptical Wing

Modeling

Rapid prototyping

Fig.1 Elliptical wing

Table.2 Specifications of the Elliptical Wings

Material	Vero White Plus (RGD835)
Chord Length	60mm
Aspect Ratio *AR*	8
Thickness	1.5mm

Table.3 Coating film thickness

Coating method	①	②	③
Brushing material	melamine sponge	both of brushing materials ① and ③	microfiber cloth
Coating film Thickness	2~3μm	1μm	～0.1μm

There are kinds of coating method depending on brushing material such as melamine sponge and microfiber cloth.

Three dimensional printer is used for manufacturing the above mentioned wings. The type of this printer is Poly-jet. In this method, a resin of which laminating pitch is 28μm is sprayed to the build tray.

PIV Measurement System

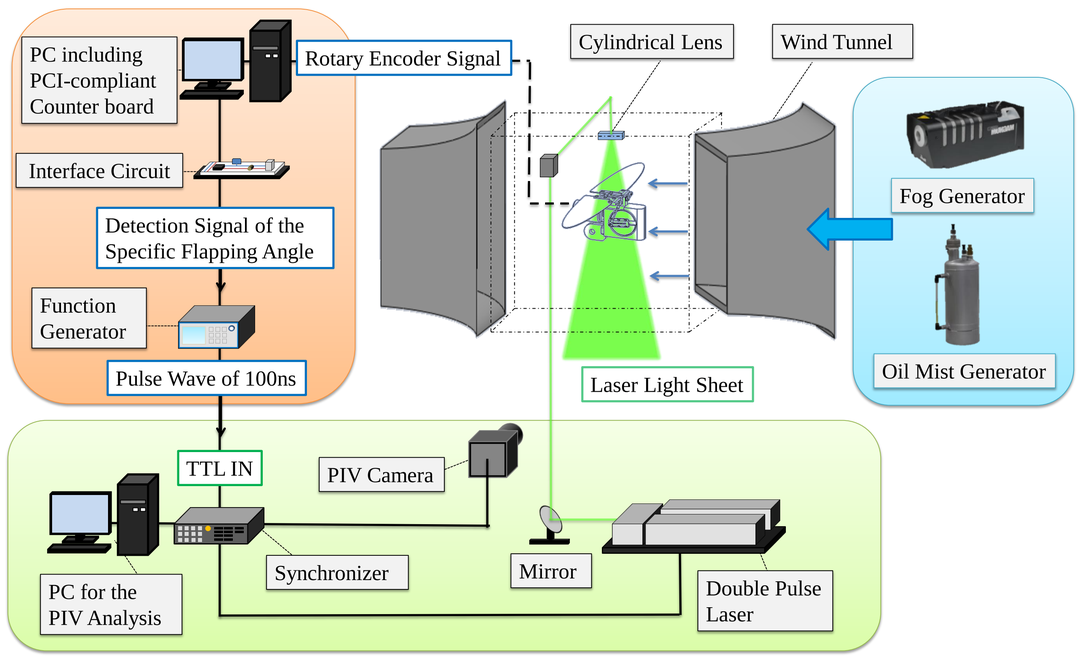


Fig.2 Schematic view of the PIV system

We have developed a synchronization system of laser irradiation and flapping angle to perform the PIV measurements for the leading edge vortex to investigate quantitatively the effect of flapping motion in detail.
1. By counting the signals of the rotary encoder, the specific flapping angle is detected.
2. At the same time as the detection, the digital signal is output to the TTL IN terminal of the function generator.
3. Double Pulse Nd:YAG Laser is irradiated by a pulse wave from the synchronizer of external mode with above TTL signal of 100 ns as a trigger.

By injecting tracer of two kinds(Glycol and Olive Oil), we succeeded in obtaining a clearer visualized image.

Measurements of Fluid Forces

Table.4 Experimental conditions

Uniform flow velocity *U*	7 m/s
Angle of attack α	0º～30º, $\Delta\alpha$=2º
Flapping frequency *f*	0(fixed),7Hz
Flapping amplitude *FA*	0º(fixed) ,20º
Data sampling frequency	1 kHz
Data sampling time *t*	20sec

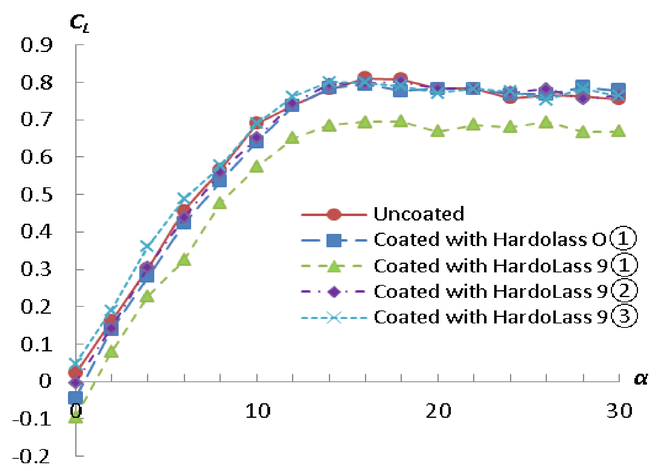


Fig.3 Lift curves

At this time, five kinds of coating conditions have been tested regarding fluid force measurement.

From the figure of drag curves, the effect of coating material is not identified.

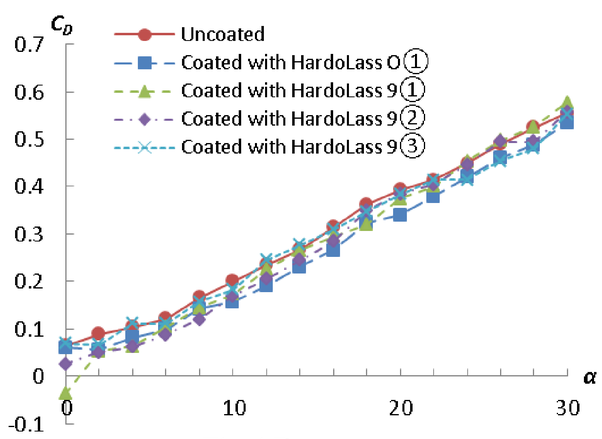


Fig.4 Drag curves

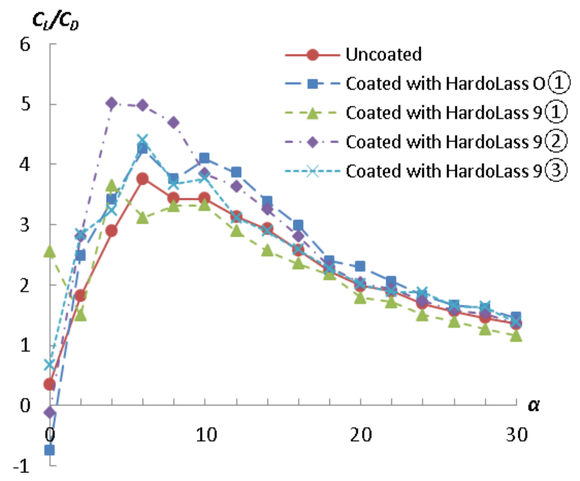


Fig.5 Lift-drag ratio curves

The C_D value of any other coating conditions are less than uncoated one. The C_D value of HardoLass O① is less by 13.5% than uncoated one at attack angle α=20º.

The C_L/C_D value of HardoLass 9② is large in the angle of attack range from 4º to 8º.

Concluding Remarks

(1) The coating material reduces a drag under appropriate coating method.
(2) The relation between the drag reduction effect and fluid phenomena will be considered depending on high accurate PIV measurement.

Acknowledgements

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