

# Consideration by discharge photographing of thruster using surface arc discharge

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## 1. Background & Purpose

In recent years, the launch of micro satellites has been increasing. The reasons are factors such as low development cost and risk allowance. In the future, as missions become more diversified, there is a need for attitude control and orbit change. So, development of a thruster that can be mounted on a micro satellite becomes necessary. The purpose of this research is the development of a surface arc thruster that can be mounted on a micro satellite. This time, in order to verify whether Teflon can be consumed uniformly by using a ring type magnet, I shot surface arc discharge using a high speed camera and measured impulse bit of the thruster.

## 2. Research principle

I explain the principle of surface arc thruster. The surface arc thruster uses Teflon as a propellant and controls the discharge current using a current regulative element. This aim is efficient Teflon consumption by flowing current for a long time. I explain the principle of propulsion. First, a small amount of Teflon is sublimed by discharge of an igniter, which spreads between both poles, and surface arc discharge is formed. After that, the gas sublimed by the arc discharge is exhausted through the nozzle, so that thrust is obtained.

The purpose of using a ring type magnet is uniform consumption of Teflon. By installing a thruster at the center of the ring magnet, Lorentz force acts on surface arc discharge, and discharge moves inside the thruster. Therefore, it will be possible to uniformly consume Teflon because energy is added to the entire Teflon.

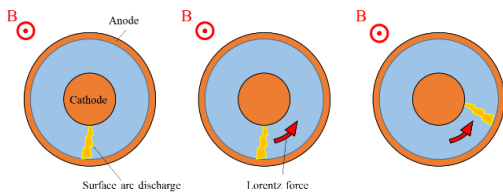


Fig1 Movement of discharge by magnet installation

## 3. Experiment method

For surface arc discharge photographing, I used thruster samples of Fig 2 and 3. The thruster is a coaxial structure and is used a copper for the anode and cathode, and Teflon is inserted as a propellant between both poles. CRD is used for current regulative control. In Fig 3, the thruster is installed at a center of ring magnet. In an impulse bit measurement, I used a thruster of Fig 5.



Fig2 Thruster (no magnet)

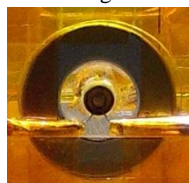


Fig3 Thruster (with magnet)

Impulse bit calculation was performed using the measurement mechanism of Fig 4 and following equation.

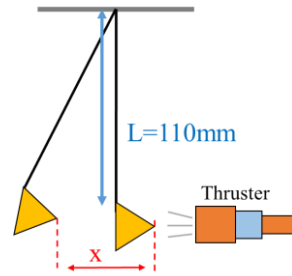


Fig4 Measurement mechanism

$$I_{bit} = M \sqrt{2g(L - \sqrt{L^2 - x^2})} \text{ [Ns]}$$

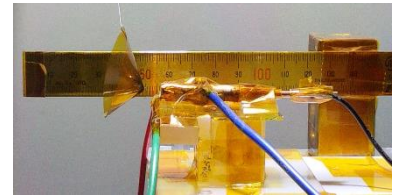


Fig5 Thruster (with nozzle)

## 4. Experiment result

In case of no ring magnet, movement of discharge was not observed, but in case of magnet, discharge propagation was confirmed in surface discharge photographing.

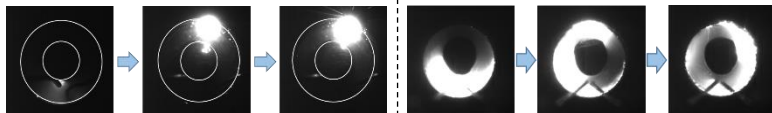
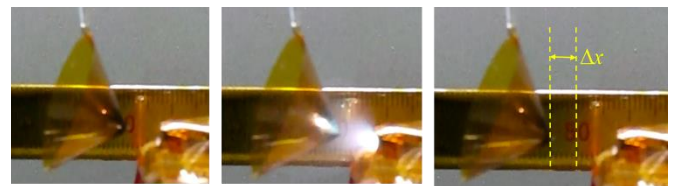


Fig6. Discharge (no magnet)

Fig7. Discharge (with magnet)

In impulse bit measurement, target moved 5mm. Therefore, the impulse bit can be calculated as follows by substituting  $x = 5mm$  and  $M = 3.4 \times 10^{-5} kg$  into the above equation.

$$I_{bit} = 1.6 \mu Ns$$



Before injection

Injection

After injection

Fig8 Thruster injection

## 5. Summary

From the surface discharge photographing, it can be considered that uniform consumption of Teflon is possible because it was confirmed that the discharge moves across the entire Teflon surface by using the ring type magnet. Also, as a target moved due to injection of thruster with the nozzle, the operation as a thruster could be confirmed, and the impulse bit of the thruster could be obtained from calculation.

Hereafter, it will be necessary to design an optimum nozzle and create a current regulative circuit that can withstand high voltage. It is also necessary to measure Teflon consumption and impulse bit change by continuous injection for a long time.