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A. *Components design*

The thruster uses a coaxial type head parts and Fig. **19** shows the design of the head parts. A φ2mm CFRP rod is inserted into an insulator tube, which is further inserted into the metal cylinder. This cylinder's outer and inner lid is fixed to the satellite body. The fixation method of the head part is shown in Fig. **20**. To prevent unexpected accidents from discharge, the thruster system is electrically insulated from the satellite body.

The capacitor is mounted to the Printed Circuit Board 1 (PCB1). The current probe used for obtaining the discharge current of the vacuum arc is mounted to the PCB2 and head part is fixed to the PCB3.

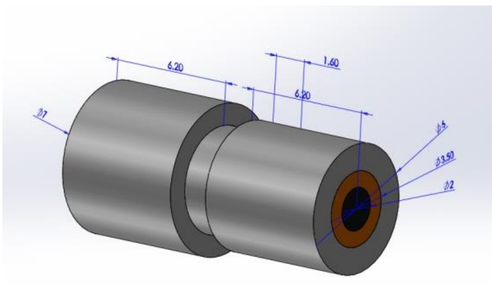

Fig. 19. Thruster head parts design

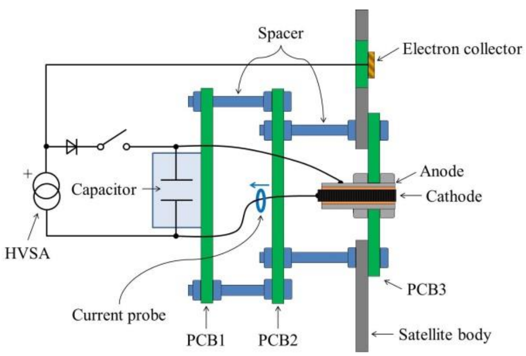

Fig. 20. Mounting method of VAT head parts

B. *Ability estimation*

From thruster operation, HORYU-IV induced angular velocity was estimated. The thruster head is mounted on the +Z panel and the moment of inerita I [kg・m^2] for each axis of HORYU-IV is shown in Eq. 4 as well as the vector r [m] from the satellite center of mass to the thruster head. Thrust is assumed to be 0.2μF from experiments. Thrust F [N] generated by the vacuum arc thruster is shown in Eq. 6. The resulting torque M [N・m] is calculated using Eq. 7. When operating the thruster for 1 minute, the satellite angular velocity ω [rad/s] was calculated using Eq. 8 where the operating time is t [s] = 60 seconds.

$$\boldsymbol{I} = (I_x, I_y, I_z) = (0.293, 0.321, 0.313) \quad \text{Eq. 4}$$

$$\boldsymbol{r} = (r_x, r_y, r_z) = (123.25\times10^{-3}, -122.24\times10^{-3}, 94.39\times10^{-3}) \quad \text{Eq. 5}$$

$$\boldsymbol{F} = (F_x, F_y, F_z) = (0, 0, 0.2\times10^{-6}) \quad \text{Eq. 6}$$

$$\boldsymbol{M} = \boldsymbol{r}\times\boldsymbol{F} = \begin{vmatrix} \boldsymbol{i} & \boldsymbol{j} & \boldsymbol{k} \\ r_x & r_y & r_z \\ F_x & F_y & F_z \end{vmatrix} = (-24.4\times10^{-9})\boldsymbol{i} - (24.7\times10^{-9})\boldsymbol{j} \quad \text{Eq. 7}$$

$$\begin{aligned} \boldsymbol{\omega} &= (\omega_x, \omega_y, \omega_z) \\ &= \frac{180}{\pi}\times t\times\left(\frac{\mathrm{M_x}}{\mathrm{I_x}}, \frac{\mathrm{M_y}}{\mathrm{I_y}}, \frac{\mathrm{M_z}}{\mathrm{I_z}}\right) \\ &= (2.87\times10^{-4}, 2.64\times10^{-4}, 0) \end{aligned} \quad \text{Eq. 8}$$

VI. CONCLUSION

In this paper, passive operation of the vacuum arc thruster using CFRP propellant was demonstrated since a stable 0.07Hz arc rate was experimentally obtained. The thrust generated by the presented vacuum arc thruster could be controlled by controlling the amount of energy stored in the capacitor. When the charged electric power was large, the thrust from the vacuum arc became large. The relationship between thrust and power was estimated to be 4.7μN / W.

Kyushu Institute of Technology is developing the "Arc Event Generator and Investigation Satellite (AEGIS), HORYU-IV". The vacuum thruster is under development to be mounted on-board HORYU-IV, which launch is planned for 2015. This will allow the proposed vacuum arc thruster to be tested on orbit from which useful data could be retrieved.

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