Influence of an Insert with a Cylindrical Core on Hollow Cathode Performance

Presented at the 33rd International Electric Propulsion Conference,
The George Washington University • Washington, D.C. • USA
October 6 – 10, 2013

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Abstract: Hollow cathodes used in electric propulsion always have a cylindrical insert. It is well-known that because of hollow cathode effect, this type of cathode has larger emission current density and lower discharge voltage. An American named Gijsbert present a double tube hollow cathode configuration which has two tubes that have different diameters in 1976. When operating, the inner tube has higher temperature, and the cathode has stronger hollow cathode effect, thus it can have lower discharge voltage. On the other hand, it is an important issue in the design of insert how to get large surface area in small space. Due to the limitation of material, the emission current density of insert must be controlled in a specific range. As a result, the insert must have a certain surface area. While smaller volume is beneficial to heating and heat preservation of cathode. This paper presents an insert with a cylindrical core, and the experimental measurements of discharge performance of this insert.

The insert with a cylindrical core is shown in figure 1. This paper has also measured the performance of an insert which has the same size except the core as comparison. Both inserts are made of LaB6. The hollow cathode used in experiments can change insert so as to compare the two inserts. There are two thermocouples placed in the cathode to measure the temperature, one placed at the heater wire, the other placed at the base. Experimental facilities also include a vacuum system, power components, and feed system.

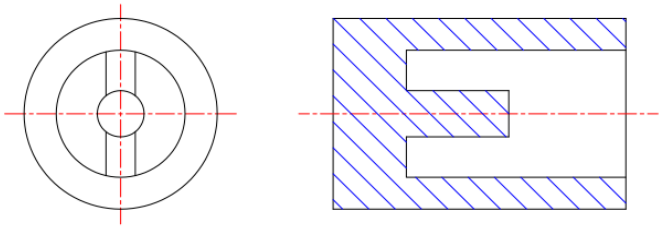

Figure 1. Insert with a cylindrical core.

Experimental results of changing anode current are shown in figure 2. It shows that the insert with a cylindrical core has better performance. The anode voltage is lower, and at low discharge current the difference is large. This

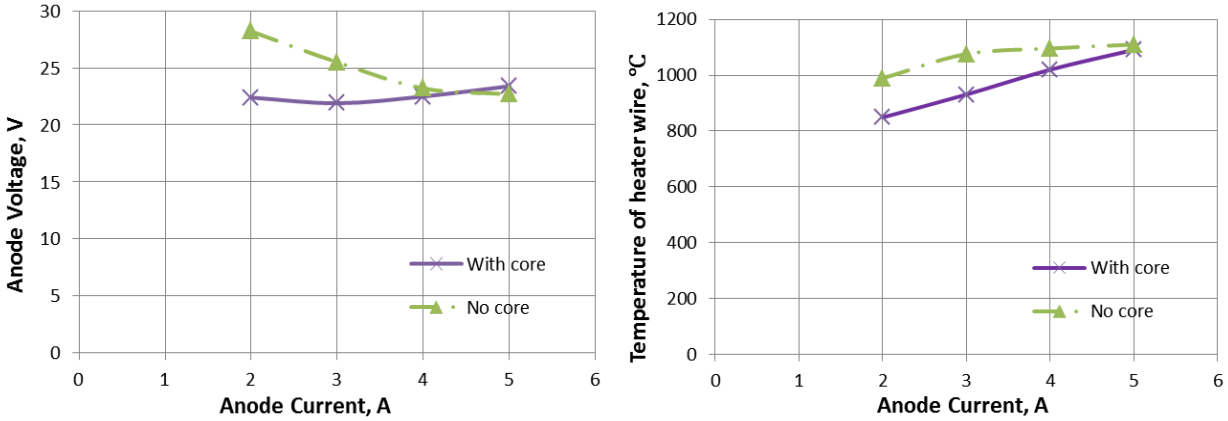

Figure 2. Comparisons of performance of insert with core and insert without core.

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indicates that the insert with a core has stronger hollow cathode effect; the temperature of heater wire is lower, which indicates that the temperature of outer surface of insert is also lower.

In the insert region of the hollow cathode, the plasma densities are higher around the orifice, and lower upstream. The core reduces the electric potential on the axis, and thus enhances the hollow cathode effect there. This should increase the plasma density, and ionizes more gas, which result in lower anode voltage. Because the core is surrounded by plasma, and is difficult to dissipate heat, the temperature of core should be much higher than other parts. Thus it would have larger emission current density, so the specific value of emission current of core and other parts is larger than the specific value of surface area. It is the reason why the temperature of insert with core is much lower. And this can increase the life of insert.

The experimental results also show that at large discharge current, the performance of insert with core has no advantages. This may because the plasma density is high so that the core enhances the diffusion losses to the wall. In addition, experiments show that the length of the core has large influence on its performance. It is bad if the core is too long. A tentative inference on this result is that it will block the flow of electrons to the orifice. To get a beneficial performance, the core should have an appropriate length.