Construction of an Arc-Heated Wind Tunnel Environment for Simulating Atmospheric Re-entry Environment and Suppression of Cathode Wear and Tear

No.2181204 Shogo Iizuka
(Supervised by Associate Prof. Ai Momozawa)

ABSTRACT

Our laboratory aims to construct an arc-heated wind tunnel to create an environment for the development of a thermal protection system that will lead to the return of reusable space vehicles such as the Space Shuttle. In this study, we constructed an arc-heated wind tunnel by connecting various devices. However, one of the problems with the arc-heated wind tunnel is that the electrodes are oxidized and worn out by the flow of oxygen. Therefore, we also performed surface modification of the electrode, mainly the cathode, to suppress wear and tear. The electrode material we focused on was zirconium. Tungsten, which has excellent melting point and work function, had been used in the past, but this material deteriorated as it became tungsten oxide, and a change in material was required. Therefore, we focused on zirconium, which has a good melting point and work function even after oxidation. In order to prevent further wear and tear, we applied nitriding treatment to zirconium to further reduce wear and tear.

In a surface modification experiment in which a nitride layer was deposited on zirconium, it was found that when nitriding was performed in a high-frequency induction furnace, the film thickness became thicker as the nitriding temperature increased, reaching a peak at 1450°C.

As a result of the operation of the arc heating wind tunnel with zirconium electrodes, it was found that operation for more than 10 minutes was possible when only Ar was used as the working gas, and that operation was also possible with zirconium.

In addition, when a mixture of Ar and air was used, both pure zirconium and zirconium nitride electrodes could operate for more than 30 minutes, and ZrN showed less wear and tear than pure Zr. Among the zirconium nitride electrodes, those nitrided at 1200°C showed less erosion than those nitrided at 1450°C, indicating that the thinner nitride layer is more suitable for use as an electrode.

From the above results, it was found that zirconium nitrided at 1200°C is suitable for the cathode of the arc heating wind tunnel.