Lessons Learned From the Use of Metal Halide Lamp in the ACPF Argon Cell

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1. Introduction

KAERI is currently developing an electrolytic reduction process that the high-heat-emitting and high-level radioactive nuclides (Cs, Sr) are efficiently removed from the spent fuels to substantially reduce spent fuels in terms of volume, heat release, and radiation intensity. In order to demonstrate the advanced technology of this process, the Advanced spent fuel Conditioning Process Facility (ACPF) has been constructed in KAERI. The ACPF consists of an air cell and an argon cell. An electrolytic reduction device was installed in the argon cell. In this paper, the failure of metal halide lamp used in ACPF argon cell and its failure countermeasures are described.

2. Lighting Device of ACPF Argon Cell

2.1 Outline of the ACPF Argon Cell [1]

The ACPF argon cell is operated to an argon atmosphere within the air cell. The argon cell (1.8L x 2D x 2.7H m) is isolated with leak tight from other air cell. The argon cell system consists of an argon cell, a remote handling device such as a crane and a master-slave manipulator, a lighting device, a material transfer system, a purifier, a cooler, a controller, utilities, etc. The argon cell maintains oxygen and moisture within 50 ppm, respectively.

Fig. 1. Constructed ACPF.

2.2 Metal halide Lamp and ballast

High-intensity discharge (HID) lamps are similar to fluorescents in that an arc is generated between two electrodes. The arc in an HID source is shorter, but it generates much more light, heat, and pressure within the arc tube. The followings are HID sources listed in increasing order of efficacy (lumens per watt); mercury vapor, metal halide, high-pressure sodium, low-pressure sodium.

Like fluorescent lights, HID also requires ballasts, and they take a few seconds to produce light when first turned on because the ballast needs time to establish the electric arc.

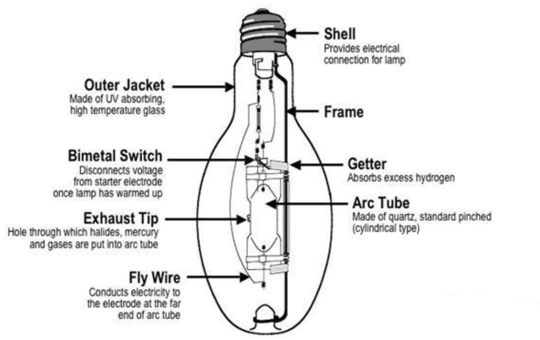

Fig. 2. Anatomy of a typical mogul-based metal halide lamp (source Venture Lighting™).

Metal halide lamps have been divided into European and American type according to the region where they are produced and used. The main difference is the lamp's tube voltage and tube current characteristics. Therefore, in Korea, they are classified as type A (European type) and type B (American type) depending on the tube characteristics. Depending on the type of ballast, CC type (high voltage generating circuit type) and RC type (peak electrostatic force type) are also called. Type A was developed to be suitable for use with CC ballast, and type B was adapted to use RC ballast. In Korea, B type lamp is mainly used.

Fig. 3. RC ballast.

2.3 Failure of cell lighting device

Fig. 4 shows the lighting device installed in the ACPF argon cell. It is equipped with one metal halide 250W lamp (B type) and one three-wavelength 100W lamp, and the ballast of the metal halide lamp is installed outside the cell.

Fig. 5 shows that an electrical spark discharge between the connector pin and the split insert carrier caused soot in the connector pin and the split insert carrier. At this time, the earth leakage breaker went down. And the CC type ballast was broken, but the RC type ballast was not broken.

Fig. 4. Cell lighting device installed in the argon cell.

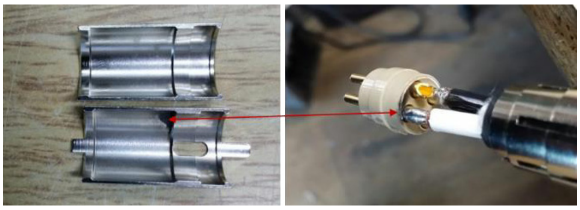

Fig. 5. Soot due to electrical spark discharge.

3. Results and Discussion

3.1 Start-up current of CC and RC type ballast

Fig. 6 shows the current up to stabilization when using the CC type ballast and the RC type ballast for a metal halide 250W lamp. In the CC type ballast, the current initially rises to 2.1A and stabilizes at 1.6A. The RC type ballast is stable at 1.2A while the current gradually increases.

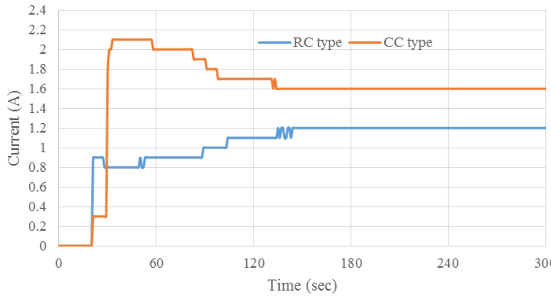

Fig. 6. Current trend until stabilization.

3.2 Failure cause analysis

If the voltage between two electrodes in the gas is increased, a spark discharge occurs at a certain value. If the electric fields between the electrodes are not equal, a light emission phenomenon occurs in a portion where the electric field on the electrode surface is large before the spark discharge, and a current of about 1~100 ㎂ flows. This is called a corona discharge. In the portion where light is generated, ionization is actively performed, current density is large, and insulation is lost.

The CC ballast has a high starting current, and the starting voltage is high when the lamp turns on. The RC ballast has a low starting current, and the starting voltage is low when the lamp turns on.

When the CC type ballast for the metal halide lamp (B type) was used in an argon environment, a corona discharge phenomenon occurred due to the high starting voltage. As a result it is considered that the dielectric breakdown occurred.

4. Conclusion

When using HID lamps in an argon environment, CC type ballasts may cause failures due to high starting currents, so RC type ballasts with low starting currents should be used. If using CC type ballasts in an argon environment, the connector pin spacing should be increased than the air environment to prevent the corona discharge [2].

REFERENCES

[1] B.S. Park, "Construction of ACPF Argon Cell using Reverse Engineering Technique", KRS 2016 Spring Conference, 14(1), 99-100, 2016.

[2] M.L. Hayward, "Environmental Hardening of Equipment Operating in an Automated Test Bed Enclosure", UCRL-ID-107864, LLNL, 1990.