Development of Dry Surface Decontamination Technology Using Low-Pressure Arc for Radioactive Waste

Background

Plasma surface decontamination technology is characterized by less secondary wastes etc., because no chemical solutions and blasts are required differently to chemical decontamination or blasting decontamination. In several types of plasma decontamination technology, Low-Pressure Arc can remove metal oxide film on metal substrate surface selectively without damage to metal substrate, so Low-Pressure Arc is expected to be most practical. Therefore we have been developing Low-Pressure Arc decontamination technology for radioactive metal waste generated during operation and maintenance of nuclear power plants *1. However, decontamination performance of Low-Pressure Arc decontamination technology was not obvious.

Objectives

To clarify the applicability of Low-Pressure Arc technology to radioactive metal waste in view point of (1) scope of applicable treatment objects, (2) ^{60}Co decontamination performance, and (3) dust correcting method at the time of Low-Pressure Arc treatment ;

Principal Results

Test pieces were applied by Low-Pressure Arc using Low-Pressure Arc decontamination equipment (Fig.1) and the following were obtained.

1. Scope of applicable treatment objects

It was clarified that metal oxide films with various chemical compositions and thickness including corrosion product films formed under condition of primary cooling system of light water reactor shown in Table 1 and Fig.2 could be removed by Low-Pressure Arc. Inner side of pipe shaped test piece also could be treated.

2. ^{60}Co decontamination performance

Argon gas at a pressure of 40Pa and carbon monoxide gas at a pressure of 40 to 700Pa were clarified as recommended treatment conditions on the kind of gas and the pressure in view of decontamination performance. More than 90% of ^{60}Co removal ratio was achieved under these conditions.

The mechanism for improving the ^{60}Co removal ratio was as follows; when removing corrosion product film, some of ^{60}Co inside corrosion product film remaining in the metal surface at around 30μ m depth. The ratio of ^{60}Co remaining depended on the pressure in the chamber and was around 20~80% of initial ^{60}Co. After that, repetition of Low-Pressure Arc treatment can make metal surface including ^{60}Co melt and evaporate, so ^{60}Co removal ratio was improved.

3. Dust correcting method at the time of Low-Pressure Arc treatment

In respect to dust correcting method using suction flow from the anode, 60% of dust correcting ratio *2 was achieved under recommended treatment conditions. So this method was considered effective.

To summarize, the possibility on application of Low-Pressure Arc decontamination technology to the radioactive metal wastes was clarified.

Future Developments

The effect of saturated vapor pressure of radionuclide on the decontamination performance will be clarified.

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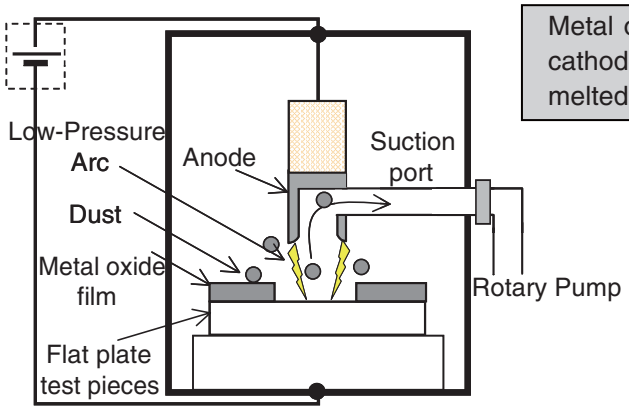
Reference

CRIEPI Report : W01004, W01011, T02026, W03017, H04019

*1 : K. Adachi *et al*., CRIEPI Report W00030

*2 : Dust correcting ratio is defined as the ratio of the dust weight removed from the test piece surface by suction flow to the dust weight remaining on the test piece surface without suction flow.



Metal oxide film on metal substrate was finally removed by cathode spots formed inside Low-pressure Arc after being melted, and vaporized.

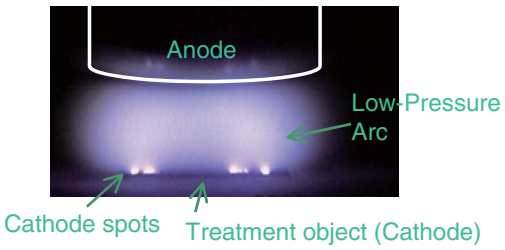
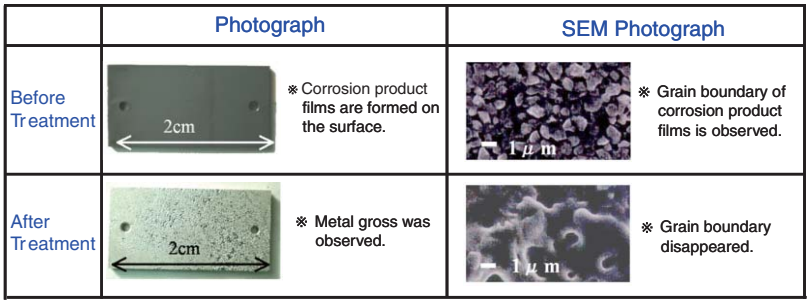


Fig.1(a) Low-Pressure Arc decontamination equipment with dust correcting function by suction flow

(b) Aspect of Low-Pressure Arc (Arc current 60A, Pressure 20Pa)

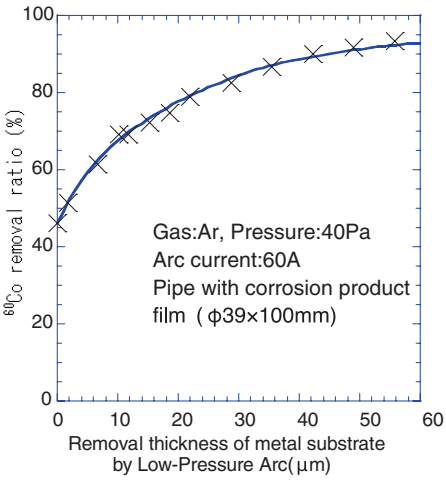
Table 1 Scope of applicable treatment objects by Low-Pressure Arc

Shape	Flat plate 10×20mm^2~100mm^2, pipe ϕ39×100mm~ ϕ114×200mm
Metal substrate	SUS304、SUS316L、SUS430、Inconnel600、S50C、SS400
Metal oxide film (Composition、Thickness)	Corrosion product films containing ^{60}Co (Fe_2O_3, $FeCr_2O_4$ etc, 1~2μ m), Heat-oxidizing metal oxide film ($FeCr_2O_4$ etc, 1~2μm), Mill scale (Fe_3O_4, 7μm), Rust (ZnO, Fe_2O_3, several hundreds of μm)



Removal of corrosion product film was confirmed.

Fig.2 An example of removal of corrosion product film



^{60}Co removal ratio is almost 50% at the time corrosion product film is removed. But ^{60}Co inside metal substrate also can be removed by repeated Low-Pressure Arc treatment and ^{60}Co removal ratio is improving.

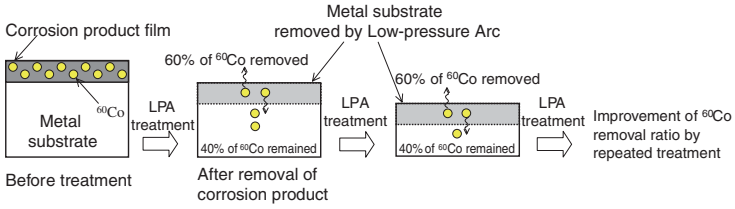


Fig.3 The relationship between ^{60}Co removal ratio and removal thickness of metal substrate