Progress of the Zinc Injection in Tsuruga NPP Unit 2

Nobuaki NAGATA*[1], Hideaki ICHIGE*[1], Eiichi KADOI*[1],
Yoshifumi WATANABE*[2], Hideya IKOMA*[3],
Tsuyoshi SEMBA*[4], Toshiaki HAMAGUCHI*[5]

***[1] THE JAPAN ATOMIC POWER COMPANY**
***[2] HOKKAIDO ELECTRIC POWER CO., INC.**
***[3] THE KANSAI ELECTRIC POWER CO., INC.**
***[4] SHIKOKU ELECTRIC POWER CO., INC.**
***[5] SHIKOKU RESEARCH INSTITUTE INC.**

1 Abstract

One of the most effective countermeasures against the radiation exposure is to reduce the radiation source. In this paper, we describe the progress of zinc injection [1], [2] in Tsuruga unit 2 (PWR, 1160Mwe, Commercial Operation started in 1987) which has over ten yeas of experience in Europe and the US for reduction of radiation source.

2 Objectives

Objectives of this study were to evaluate the zinc injection for Japanese PWR plants by using Tsuruga-2 as shown in the followings.

- Effect of water chemistry during zinc injection
- Effect of decreasing dose equivalent rate on primary equipment and pipes after zinc injection
- Evaluation of the fuel performance by observing the external appearance and thickness of oxide film on the fuel installed in core during zinc injection

3 Experimental

Depleted Zinc Oxide (DZO), which is reduced the abundance of ^{64}Zn below 1%, was used in this study due to suppression of the radiation source increasing caused by radioactivation of zinc. DZO was dissolve in acetic acid solution and was injected into primary system via the volume control tank from the sampling return line (Fig.1). The zinc injection had been performed in Tsuruga unit 2 for eight months within a range of 5-7 ppb based on the European experience. We had measured the dose equivalent rate on primary equipment and pipes during the Tsurga-2 outage from the viewpoint of checking the effect of radiation source reduction due to zinc injection. In addition, we had checked whether the zinc injection has an adverse effect on the water chemistry and fuel performance.

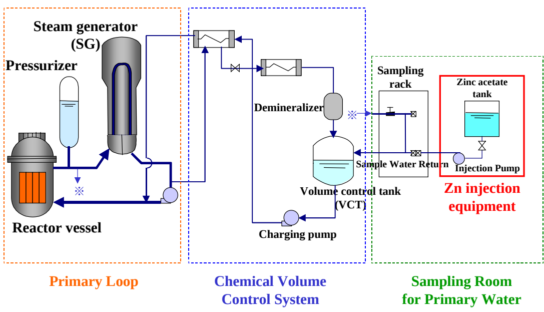

Fig.1 Zinc Injection System in Tsuruga-2

4 Results and Discussion

4.1 Effect of water chemistry during zinc injection

Measuring the properties of reactor coolant during zinc injection, concentration of the radioactive cobalt (^{58}Co and ^{60}Co) was increased by a factor of ten with zinc injection than before. The increase of radioactive cobalt was expected based on the European experience. Reactor coolant purity, such as pH and electrical conductivity, was not affected (Fig.2).

In general, single-layer or double-layer oxide films are formed on the primary equipment and pipes during exposure to the primary coolant of PWRs. The inner layer consists of a chromium-rich spinel oxide film. Zinc is thermodynamically more stable in chromium-rich spinels than ^{58}Co and ^{60}Co. Preferential incorporation of zinc in oxide layer would result in a decrease in the pickup of ^{58}Co and ^{60}Co and their dose activity on primary equipment and pipes will decrease. For this reason, the concentration of ^{58}Co and ^{60}Co in primary coolant will increase.

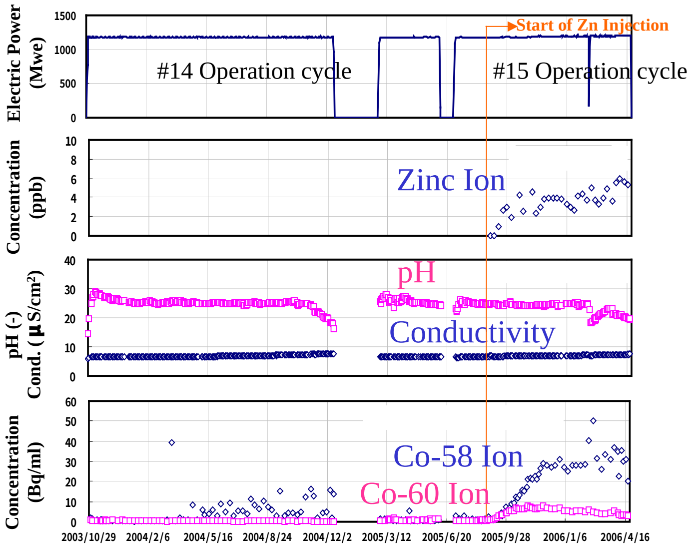

Fig.2 Primary Water Chemistry during the Zn Injection

4.2 Effect of decreasing dose equivalent rate on primary equipment and pipes after zinc injection

Measuring the dose equivalent rate on primary equipment and pipes, dose equivalent rate on main equipment and pipes (Hot-leg, Crossover-leg, cold-leg, SG channel head) was reduced to 70-80% than that of previous outage (Fig.3).

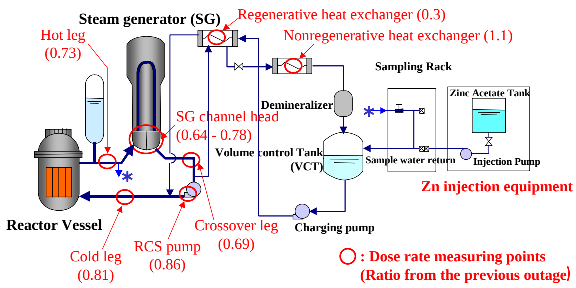

Fig.3 Relative dose equivalent rate on the primary equipment and pipes

4.3 Evaluation of the fuel performance by observing the external appearance and thickness of oxide film on the fuel installed in core during zinc injection

Fuel performance was evaluated by observing the external appearance and thickness of oxide film on the fuel installed in core during zinc injection.

In the result of visual inspection of the fuel external appearance, fuel surface was found nothing wrong and showed no significant differences with or without zinc injection.

Measuring the thickness of oxide film on the fuel, it was not considered that zinc injection would

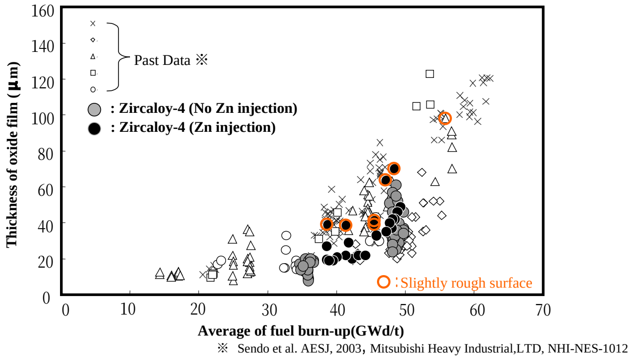

Fig.4 Measured thickness of oxide film

affect corrosion on fuel cladding because the measured thickness of oxide film was included in past database (Fig.4).

5 Conclusion

5.1 Water Chemistry

Concentration of the zinc in primary water was controlled well within the target value (5-7 ppb). Although concentration of the radioactive cobalt was increased by a factor of ten with Zinc injection than before, the increase was included within the expectation based on the European experience. The increase in Zn-65 was not found due to using depleted zinc.

5.2 Dose equivalent rate

The zinc injection reduced the dose equivalent rate of primary equipment and pipes to 70-80 % than that of previous outage.

5.3 Fuel performance

It was not considered that zinc injection for eight months would affect corrosion on fuel cladding by observing the fuel external appearance and thickness of oxide film on the fuel cladding.

Zinc injection in Tsuruga-2 will continue to be performed. Influence of long-term zinc injection on the plant and fuel performances will be estimated.

6 Reference

[1] H. Ocken et al., “Recent Developments in PWR Zinc Injection”, Proc. of the International Conference on Water Chemistry of Nuclear Reactor System, 2002

[2] B. Stellwag et al., “Short-Term and Long-Term Effects of Zinc Injection on RCS Chemistry and Dose Rates at Siemens PWR Plants”, Proc. of the International Conference on Water Chemistry of Nuclear Reactor System, 2004