HOLLOW FIBER FILTER APPLIED TO THE LATEST BWR PLANT IN JAPAN

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ABSTRACT

The quality of reactor feed water and reactor recirculating water within boiling water reactor (BWR) systems in Japan has been significantly improved recently by various measures. These water quality improvements result in reduced radiation levels within BWR's.

In the past, powdered resin precoated condensate filters have been used to remove iron CRUD from the condensate water, but the volume of secondary radioactive waste generation is still relatively large and other problems have remained unsolved.

We jointly developed two type of hollow fiber filters, and we did a hot test on them at the condensate system of the actual BWR plant and also did a cold test with an actual size test loop.

We believe that these filters will significantly improve the current problems. Results to date show that the hollow fiber filter is excellent for filtration. We have confirmed that it can be adopted to actual plants.

BACKGROUND

Iron CRUD concentration in the reactor feed water has been reduced to 0.3 ppb and cobalt concentration in the reactor feed water is reduced to 1 ppt in recent Japanese BWR plants as a result of the following measures.

1) Application of corrosion resistant steel for the main condenser.

2) Application of low-alloy steel for the feed water heaters.

3) Application of low-cobalt stainless steel for the feed water heater tubes and core internal structures.

4) Installation of the condensate filter.

Consequently, the radiation level from the primary loop has been decreased and the personnel radiation dose has been reduced.

The chemical regeneration period of deep bed demineralizers has been extended to more than one year. This extended regeneration period results in a reduction of liquid waste volume.

However, the volume of spent powdered resin as secondary radioactive waste from the precoat type condensate filter is estimated to be approximately 300 drums a year (55 gal. drums) even though its volume is reduced with plastic solidification. Therefore, further reduction of the waste volume is desired.

Based on this, we have developed a non-precoat type and backwashable hollow fiber filter and have studied its application to the condensate polishing system.

CHARACTERISTICS OF HOLLOW FIBER FILTER

This non-precoat type filter consists of porous hollow fiber made of synthetic plastic material, and is of a cylindrical shape as shown in Photos 1 and 2.

The major pore sizes of the membrane distribute to under 0.1 micron meter so that suspended solid which we frequently encounter at nuclear power station can be completely removed from liquid waste.

Utilizing these characteristics, we have successfully developed small pore size, extremely low linear velocity of filtration, backwashable, and non-precoat type filter.

Photo 1. Cross-Sectional View of Fiber Type "A".

Photo 2. Cross-Sectional View of Fiber Type "B".

APPLICATION OF HOLLOW FIBER FILTER TO BWR PLANT IN JAPAN

Application to the Radwaste System

The hollow fiber filter has been successfully applied to the radwaste/low conductivity waste treatment system at Kasniwazaki-Kariwa nuclear power station unit 1 (1100 MWe BWR) and Fukushima Daini nuclear power station unit 3 and 4 (each 1100 MWe BWR) common radwaste system in 1984.

Concentration of suspended solid in the filtrate is less than the lower detection limit (1 ppb as Fe). Excellent backwashability and other many advantages have been confirmed.

Application to the Condensate Polishing System

Hot tests of hollow fiber filter have been performed at Fukushima-Daini nuclear power station unit 1 (1100 MWe BWR) on the condensate system for over a year starting in late 1984.

The hot test loop is described in Fig. 1.

In this test system the condensate is continuously sampled from the inlet of the existing precoat type filter, and fed to two kinds of hollow fiber filters.

Furthermore, the filtrate of these two hollow fiber filter is fed to a deep bed type demineralizer and returned to the main condenser.

Hollow fiber filter unit type "A" is shown in Photo 3., type "B" in Photo 4., and demineralizer in Photo 5.

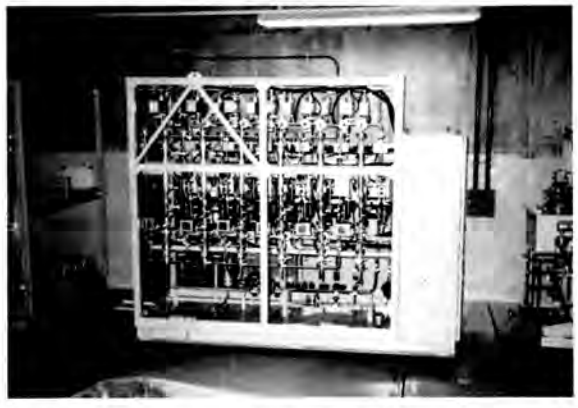

Photo 3. Type "A" Filter Test Skid.

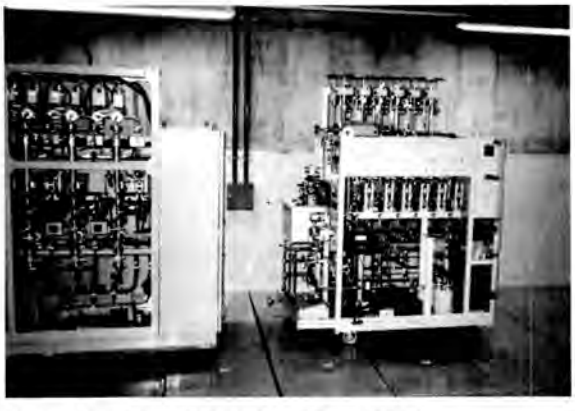

Photo 4. Type "B" Filter Test Skid.

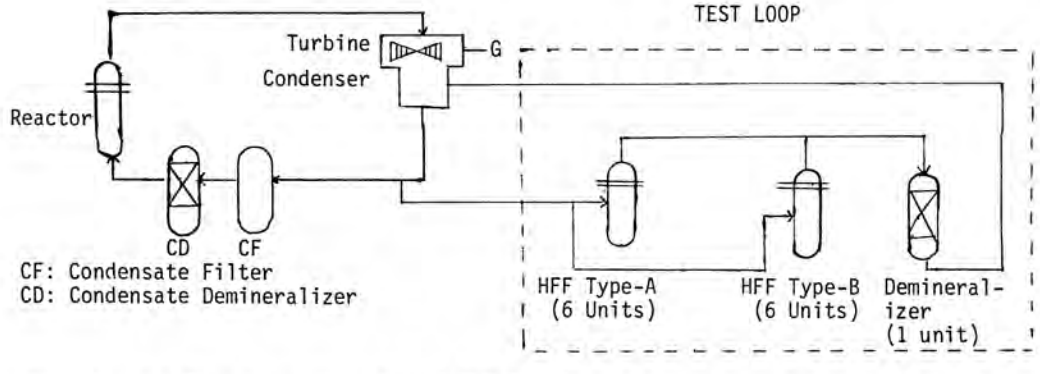

Fig. 1. Hot Test Loop at an Actual BWR Plant.

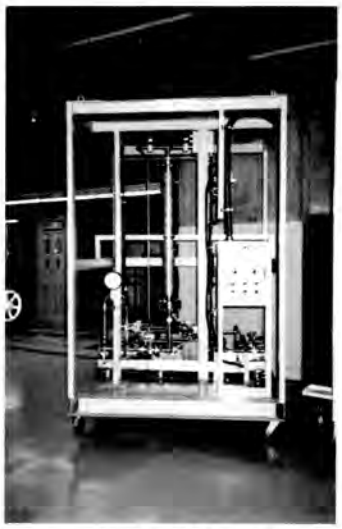

Photo 5. Demineralizer Test Skid.

During this hot test, characteristics of the hollow fiber filter for the condensate and influence of this filter on condensate demineralizer were investigated.

The test results are shown in Fig. 2 and Table I.

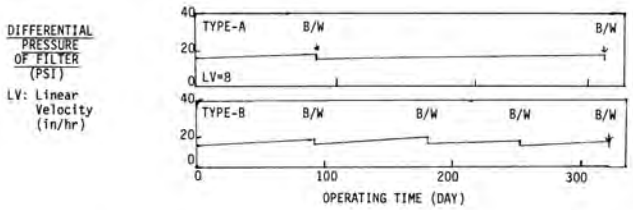

Fig. 2. Test Results of Hot Test "Differential Pressure". LV=Linear Velocity (Inch/Hour)

TABLE I

Test Result of Hot Test "Water Quality"

WATER QUALITY

SAMPLING POINT		FILTER IN	FILTER OUT	DEMI. OUT
Fe	INSOLUBLE	18 ppb	<0.01 ppb	<0.01 ppb
	SOLUBLE	0.16 ppb	0.13 ppb	<0.01 ppb
Co	INSOLUBLE	0.9 ppt	<0.2 ppt	<0.1 ppt
	SOLUBLE	2.9 ppt	2.8 ppt	<0.1 ppt

Test Results show that the concentration of suspended solid in the filtrate remain below 0.1 ppb as Fe, a very slow increase in differential pressure, and backwashability (the number of backwash cycles is predicted to be once or twice a year).

Further, the laboratory actual size cold test date confirms that the flux in the filter vessel is uniform. Moreover, there is no problem in the scale-up process at the system design.

These actual size cold test loops are shown in Photo's 6 and 7, and hollow fiber modules which are installed in these loops are shown in Photos 8 and 9.

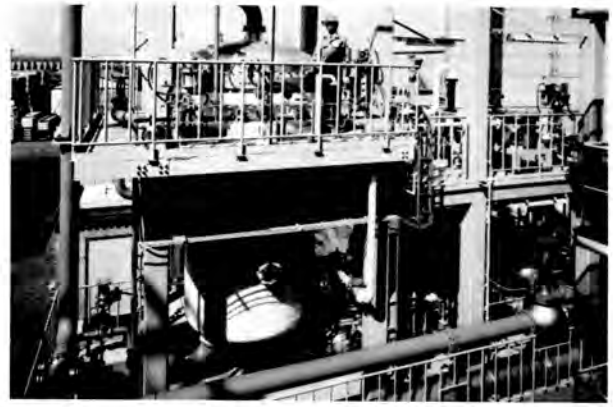

Photo 6. Actual Size Cold Test Loop of Type "A" Filter.

Photo 7. Actual Size Cold Test Loop of Type "B" Filter.

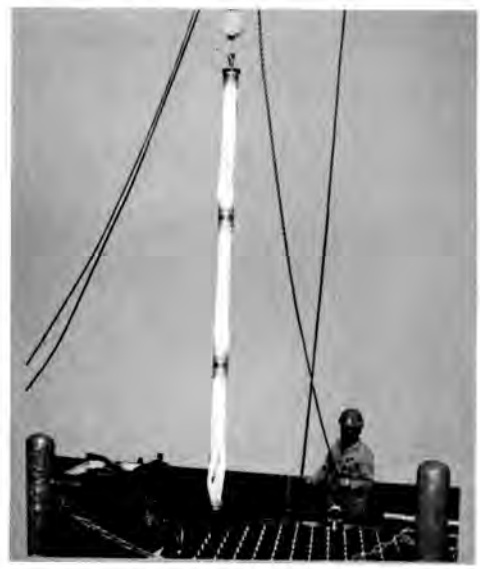

Photo 8, Hollow Fiber Module Type "A".

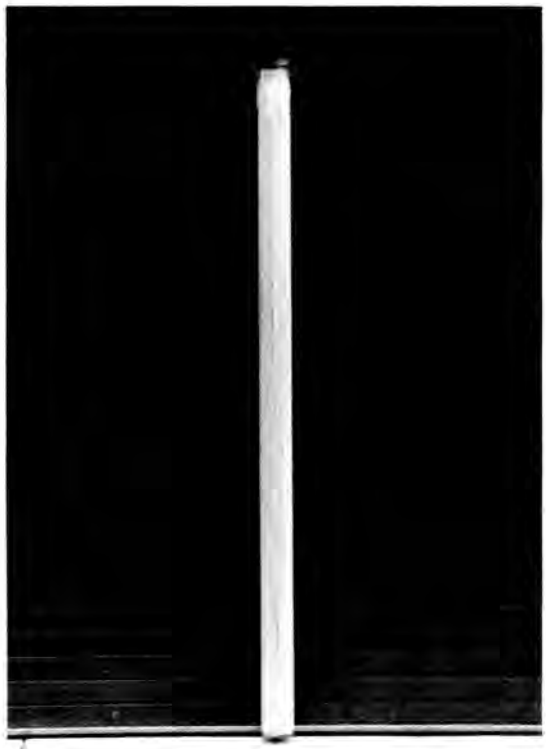

Photo 9. Hollow Fiber Module Type "B".

ADVANTAGES OF THE APPLICATION OF HOLLOW FIBER FILTER

Application of hollow fiber filter to the condensate polishing system has the following advantages:

1) No generation of spent powdered resin as a secondary radioactive waste.

   The current 300 drums a year of plasticized waste are significantly reduced.

2) Reduction of facility cost

   - 10 vessels of precoat type condensate filter can be replaced by 5 vessels of hollow fiber type condensate filter.

   - Spent powdered resin storage tanks (condensate filter sludge storage tanks).

     Currently 300 m^3 x 4 tanks can be eliminated in the case of an 1100 MWe BWR.

     The comparison of system composition between precoat type and hollow fiber type condensate filter is shown in Fig. 3.

3) Reactor feed water quality is improved from about 1 ppb as Fe by precoat type filter to below 0.1 ppb by hollow fiber filter.

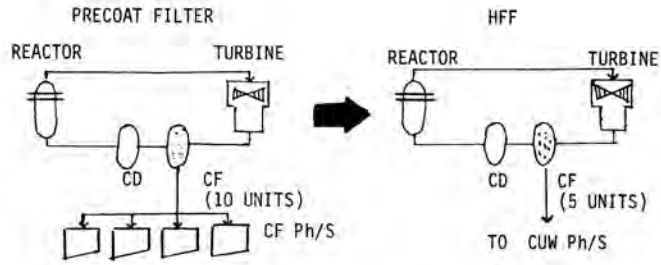

Fig. 3. Comparison of System Composition.

Based on the above-mentioned hot and cold test results it is believed that the hollow fiber filter can be successfully applied to both the radwaste system and the condensate filter system of the BWR plant.

Improvements can be made to the reactor water and the reactor feed water quality while drastically reducing the volume of secondary radioactive waste.

Further, it is expected that man-rem exposure with application of hollow fiber filter to existing plants will be significant.

FUTURE RESEARCH AND DEVELOPMENT

Improvements of the reactor feed water quality and reduction of man-rem exposure has been achieved in the latest nuclear power plants in Japan. Continued research and development including various applications of hollow fiber filter are expected to achieve further saving of man-rem exposure and reduction of radioactive waste generation.