Application of a Long Term Asset Management Strategy for HP Feedwater Heaters

Se Youl Won , Eun Sub Yun, and Young Sheop Park
Nuclear Engineering & Technology Institute, Korea Hydro & Nuclear Power Co. Ltd.,
25-1 Jang-dong Yuseong-Gu, Daejeon, KOREA, 305-343, w1310@khnp.co.kr

1. Introduction

As the commercial operating year of nuclear power plants is increased, it becomes imperative to develop integrated cost-effective asset management and to improve plans for degraded Structures, Systems, and Components (SSCs) in terms of safety and economical consideration. A long-term asset management (LTAM) strategy can improve the condition of nuclear plants, maximize their value, and optimize their operational life by maintaining their safety. This paper presents an optimized LTAM plan for HP feedwater heaters at a specific nuclear power plant.

2. LTAM strategy process

LTAM planning involves various processes that systematically identify and examine the important SSCs, and optimize their contribution to plant performance, reliability, safety, and value; long-term maintenance management plans are then presented on the basis of a technical and economic evaluation [1, 2]. Feedwater heaters are important for power production and plant efficiency, and are subject to significant operating stress and degradation. Moreover, the major failures of feedwater heaters are frequently occur as a result of tube erosion, shell thinning, impingement plate damage caused by tube-and-tube collisions, fretting, support plate fault stream erosion, FAC, and improper installation of impingement plate.

In this case, the tubing of the feedwater heaters is made of carbon steel (Steel TU 42C). Because tubes made of carbon steel last approximately used for 20 years, there is a gradual increase in the tube erosion and thinning rate. Currently, the rate at which damaged or leaking tubes are plugged is rapidly increased. Furthermore, additional costs arise from the loss of power that occurs when the damaged tubes of feedwater heaters are plugged.

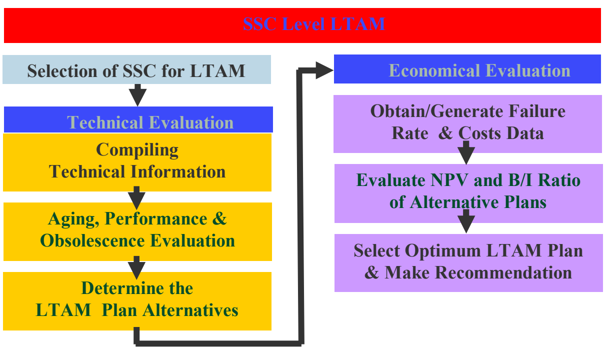

Fig. 1. LTAM strategy process

This paper presents technical and economic evaluations on the basis of the LTAM strategy shown in figure 1. The evaluations of this case are then used to present an optimized LTAM plan.

2.1. Technical Evaluation

Depending on the selection of tube material, the design considerations, and the operating conditions, the average life of a feedwater heater is 15 to 25 years. The average life expectancy of feedwater heaters with tubes made of carbon steel is 12 years, whereas that of feedwater heaters with tubes made of stainless steel, such as monel, is more than 30 years [3, 4]. In this case, the tube damage caused by leakage occurs mainly around the impingement plate. This phenomenon is attributed to the tube erosion that occurs easily in carbon steel tube due to the extraction steam. When carbon steel tubes are used in feedwater heater for periods as long as approximately 20 years, the extraction flow rate is imbalanced in each train. Furthermore, as a result of Heat Transfer Research Institute (HTRI) which is a program for predicting thermal performance, the Terminal Temperature Difference (TTD) and Drain Cooler Approach (DCA) are degraded by about 0.72°C and 0.33°C, respectively at a tube plugging rate of 5.98%. Table 1 presents the results of HTRI. Failure of the feedwater heater is prevented by an increase of NDE inspections; in addition, major maintenance should be undertaken with regard to re-tubing, re-bundling, and replacement of feedwater heater, particularly in light of a technical evaluation of the performance degradation of the feedwater heater and any increase in the leakage of the carbon steel tubes.

Table 1: Thermal Performance Analysis using HTRI

Items	Units	Design	Current	Degradation	Ref.
Tube No.	each	1,672	1,572	99 tube plug	5.92%
Heat Duty	kcal/kg	65.94×10^6	63.66×10^6	2.28×10^6	3.48%↓
Velocity	kg/m²	2.02	2.1	0.08	3.67%↑
Diff. Press.	bar	0.47	0.503	0.033	7.02%↑
TTD	°C	2.78	3.5	0.72	25.8%↑
DCA	°C	5.56	5.89	0.33	5.94%↑

2.2. Economic Evaluation

Three alternative LTAM plans are determined on the basis of the economic evaluation. In plan A the current maintenance activity continues for life span of 40 years or 60 years. In plan B, three are more NDE examinations of the feedwater heater. In plan C, the feedwater heater is replaced. Plants that are licensed to operate for 40 years or 60 years need to have their licenses renewal. The economic evaluation is conducted with the aid of an Life Cycle Management (LCM) value tool developed by the by EPRI. The LCM value program, which is based on a Microsoft Excel spread sheet, calculates the Net Present Value (NPV) by using the cost data; it then compares this value with other alternatives. Figures 2 and 3 show the results of the LCM value applied to this

2.2.1 Plant Strategy 1: 40 years

The results in figure 2 show that plan 1C in which the feedwater heater is replaced, is more economical than plans 1A and 1B. Actually, plan B which optimizes the PM tasks such as the ECT test, has no economical benefit over the base case (plan. 1A). In plant strategy 1 (for a design life of 40 years), plan 1C is the most beneficial plan because the B/I ratio of plan 1C has the highest value of all the plans.

2.2.2 Plant Strategy 2: 60 years

The results in figure 3 show plan 2C in which the feedwater heater is replaced, is more economical than plans 2A and 2B, and these results are confirmed by the Benefit vs Investment ratio (B/I ratio) in figure 3. Moreover, in spite of the high initial investment cost of replacing the feedwater heater, the B/I ratio confirms that plant strategy 2 (for a license renewal after 60 years), in which the commercial operation continues for 60 years, is more economical than plant strategy 1.

Summary of Analysis Results

Alternative	Description		Analysis Results: Net Present Value Cost - Nominal	Analysis Results: B/I Ratio (relative to 1A)
1A	Base Case - Current Activity will continue to the end of 40 years term	PM	$865K	N/A
		CM	$610K	
		Lost Production	$3,453K	
		Consequential Costs	$0K	
		Total	$4,928K	
1B	Optimize PM Task(ECT Test)	PM	$12,423K	-0.96
		CM	$492K	
		Lost Production	$3,113K	
		Consequential Costs	$0K	
		Total	$16,028K	
1C	Replacement of Feedwater Heater(2009 year)	PM	$3,612K	0.39
		CM	$39K	
		Lost Production	$202K	
		Consequential Costs	$0K	
		Total	$3,854K	

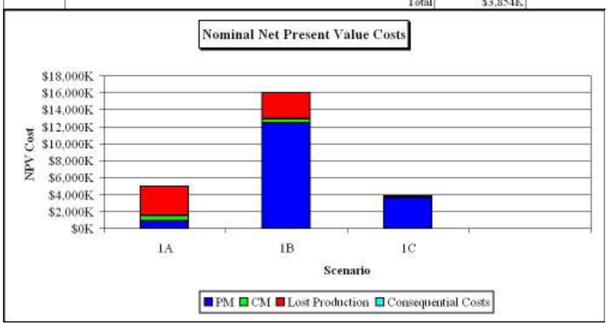

Fig. 2. The result of economic evaluation for Plant Strategy 1 (40 years).

Summary of Analysis Results

Alternative	Description		Analysis Results: Net Present Value Cost - Nominal	Analysis Results: B/I Ratio (relative to 1A)
1A	Base Case - Current Activity will continue to the end of 60 years term	PM	$1,416K	N/A
		CM	$1,439K	
		Lost Production	$7,795K	
		Consequential Costs	$0K	
		Total	$10,650K	
2B	Optimize PM Task(ECT Test)	PM	$20,289K	-0.94
		CM	$1,155K	
		Lost Production	$6,943K	
		Consequential Costs	$0K	
		Total	$28,387K	
1C	Replacement of Feedwater Heater(2009 year)	PM	$4,163K	2.26
		CM	$51K	
		Lost Production	$239K	
		Consequential Costs	$0K	
		Total	$4,453K	

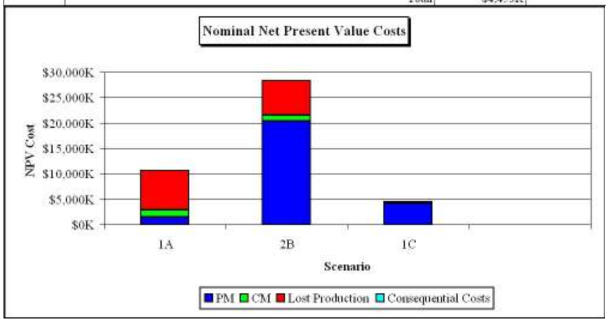

Fig. 3. The result of economic evaluation for Plant Strategy 2 (60 years)

3. Conclusions

The proposed way of improving the LTAM and the long-term condition of feedwater heaters is summarized as follows on the basis of the economic evaluation : the feedwater heater should be replaced whenever the tube plugging limit is reached or the thermal performance is measurably degraded or the tube experiences a failure mechanism.

Currently, there is a continual decrease in the performance degradation of a feedwater heater as a result of tube leakage. This degradation, which is attributed to the tube erosion mechanism of steam extraction and prolonged usage, diminishes the integrity of carbon steel tubes. The results of the technical evaluation show that the feedwater heater needs to be maintained to optimize the PM task or changed at a suitable replacement time. Furthermore, the results of the economic evaluation suggest that the replacement of the feedwater heater is the optimum solution, and that plant strategy 2 is the most beneficial LTAM strategy in this case.

REFERENCES

[1] EPRI, Life Cycle Management Sourcebook – Overview Report, 1003058, December 2001.
[2] EPRI, Life Cycle Management Sourcebook – Volume 10 : Feedwater Heaters, 1009073, December 2003.
[3] EPRI, Feedwater Heater Technology Symposium, 1004121, Proceedings August 2004.
[4] EPRI, Feedwater Heater Maintenance Guide, 1003470, May 2002.