Projection of a Spent Fuel Arising Using Three Estimation Models

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1. Introduction

Recently, government, academic society, and industry are trying to propose a national plan for a long-term safe management of spent fuels. It is valuable to predict a variation in the amount of spent fuels resulting from a technology development for a fuel performance and other reactor operation strategies. It is well known that the amount of spent fuel accumulated in the future can be changed with the functions of a discharge burnup, cycle length, batch size, and the number of reactors.

In this study, a exploration of spent fuel arising was done using a program developed at KAERI to estimate the amount of spent fuel resulting from a change of the parameters mentioned above.

2. Description of Model and Program

2.1 Projection Model

Three models were proposed for the analysis of spent fuel arising. Following Eq. (1), (2), and (3) represent, respectively, reactor cycle model, discharge burnup model, annual average discharge model. In all equations, C_f^k, C_c^k, and L_c^k represent amount of spent fuel to be accumulated, amount of spent fuel accumulated by previous time, and total amount of spent fuel in a core for unit *k*, respectively. And, remaining reactor operation period is declared by *n* on the year-base.

Model 1: Reactor cycle model

$$C_f^k = C_c^k + \sum_{i=1}^{n} \frac{L_c^k}{N_b} \int_t^{t+0.99} \delta \left[\sin\left(\frac{\pi}{M_c^k/12}(t-t_b) \right) \right] dt + L_c^k \quad \text{------ (1)}$$

where, N_b = number of batchs for unit *k*,
t = calendar year for remaining operation period,
M_c^k = cycle length [month],
t_b = base year.

Model 2: Discharge burnup model

$$C_f^k = C_c^k + 365 \sum_{i=1}^{n} P^k \frac{L^k}{\varepsilon^k} \frac{1}{B^k} + L_c^k \quad \text{------ (2)}$$

where, P^k = electric power output[MWe] for unit *k*,
L^k = capacity factor for unit *k*,
ε^k = thermal efficiency for unit *k*,
B^k = discharged burnup[MWD/MtU].

Model 3: Annual average discharge Model

$$C_f^k = C_c^k + \sum_{i=1}^{n} D_{avg}^k + L_c^k \quad \text{------ (3)}$$

where, D_{avg}^k = annual average discharge rate[MtU/yr] for unit *k*.

The Model 1 and 2 can analyze the decreasing amount of spent fuels resulting from long-cycle operation strategy. The Model 1 can assess the amount of spent fuels caused by the cycle length extension. The Model 2 can respond to the enhanced discharge burnup.

2.2 Description of Program

The program, SPENJEC, was developed by Visual Basic under XP Windows environment. This includes three models explained above and domestic reactors, namely, PWRs, CANDUs, and HANARO. It is equipped with graphic user interface. Detailed description of the program will be presented in this conference[1].

3. Results and Discussions

At first, the reference data was evaluated to compare this value with other values that might be available as a result of other reactor operation strategies. And then, the estimation of the spent fuel arising was done by applying different parameters only for PWR the reactors only.

In the reference case which assumes that the current commercial reactors would be operated by the current licensing period, it revealed that the amount of spent fuel would be approximately 37,500 tons of spent fuels, ~22,500 tons from PWR reactors and ~15,000 tons from CANDU reactors. Figures 1 and 2 show the data windows for the amount of spent fuels to be produced for each unit, and the total amount of spent fuels projected from different models for the reference case.

For the case where the cycle length for a Westinghous-type(WH) and a Korea Standard type(KSNP) is extended to 18 months, the reduction of 400 tons of spent fuels is expected. The reference case was simulated by applying a 17-month cycle length for these reactors. For the case where the discharge burnup of the WH and KSNP is extended to 55GWD/MtU, the reduction of 700 tons of spent fuel is expected. The reference case was simulated by applying 50 GWD/MtU for these reactors. If the life-time of the WH and KSNP is extended to 50 and 60 years, the reduction of 3,400 and 6,700 tons of spent fuels is expected, respectively.

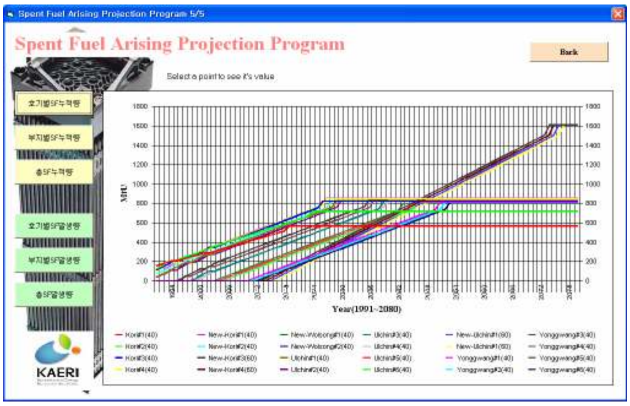

Fig. 1. Amount of spent fuels to be produced for each unit projected by different models.

Fig. 2. Total amount of spent fuels projected by different models.

4. Conclusions

In this study, projection of spent fuel to be produced was performed by considering various circumstances. For the case where the cycle length for the WH and KSNP was extended to 18 months, the reduction of 400 tons of spent fuels was anticipated. For the case where the discharge burnup of the WH and KSNP was extended to 55GWD/MtU, the reduction of 700 tons of spent fuel was estimated. If the life-time of the WH and KSNP was extended to 50 and 60 years, the reduction of 3,400 and 6,700 tons of spent fuel would be realized, respectively. It is expected that the developed program will be widely used for a projection of a spent fuel arising by considering various reactor operation strategies

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REFERENCES

[1] J. H. Cha, "Development of Spent Fuel Arsing Projection program," Transactions of the Korean Nuclear Society Spring Meeting, Gyeongju, Korea, May 29-30, 2008 (2008).