Basic Research about Calculation of the Decommissioning Unit Cost based on The KRR-2 Decommissioning Project

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1. Introduction

The Korea Atomic Energy Research Institute (KAERI) have carried out Decommissioning for Korea Research Reactor-2 (KRR-2), Uranium Conversion Plant (UCP). KAERI is performing research for calculation of expected time of a decommissioning work and evaluation of decommissioning cost and this research calculate a decommissioning work unit productivity based on decommissioning activity experience data for KRR-2.

The KAERI be used to calculate the decommissioning cost and manage the data of decommissioning activity experience through systems such as the decommissioning information management system (DECOMMIS), Decommissioning Facility Characterization DB System (DEFACS), decommissioning work-unit productivity calculation system (DEWOCS) [1].

Some country such as Japan and The United States have the information for decommissioning experience of the NPP and publish reports on decommissioning cost analysis. These reports as valuable data be used to compare with the decommissioning unit cost. In particular, need a method to estimate the decommissioning cost of the NPP because there is no decommissioning experience of NPP in case of Korea.

In this paper, in the absence of dismantling experience in the NPP, introduce a calculating method for predicting the decommissioning cost among the decommissioning targeted facility such as the NPP. Also, using the decommissioning experienced data of the other nations, predict and compare with the decommissioning unit cost of the NPP through matching the similar facilities between NPP and dismantled nuclear facilities in each country.

This paper is organized as follows. The chapter 2 discusses the calculating methods of the decommissioning Unit Cost in the KRR-2, Japan Power Demonstration Reactor (JPDR) and Vermont Yankee Nuclear Power Station (VYNPS) and then introduce the matching table about similar the decommissioning targeted facilities such as the NPP.

2. The calculating methods of the decommissioning unit cost in the each country

2.1 The calculating method decommissioning unit cost in the KRR-2

We divided the earned data in the KRR-2 into a Facility Code and a WBS Code. After then, this data have built in the database [1]. This WBS Code have seven kinds of attributes about decommissioning work field. Each of the attributes are defined as dismantling work (GD), maintenance (GE), radiation/radioactivity management (RP), radioactivity waste management (WM), quality management (QC), expert application (SE), and common job (CO). Each of the work fields are expressed as a unit of man-hour/area, man-hour/volume, man-hour/weight.

Table I : Unit cost factor of the K2-9.3

Total weight of K2-9.3 : 15,340kg

Work Field	(m-h/kg)
GD	0.0137
GE	0.0001
RP	0.0057
WM	0.0015
QC	0.0021
SE	0
CO	0
SUM	0.0231

For example, when working on dismantling in the Heat Exchanger, the decommissioning targeted facility of total 15,340kg is classified as GD, GE, RP, WM and QC in work field and recorded each the unit productivity factor. As shown in Table I, the K2-9.3 is a WBS Code and is presented unit productivity factors about each of the attributes for work field that is relevant to “Dismantling work for the Heat Exchanger of KRR-2”. This total unit productivity factor is 0.0231m-h/kg and this factor presented weight per one hour to work.

For calculating the Decommissioning unit cost of the KRR-2 need to labor cost per one hour. This labor cost use to provide the government labor cost on the Construction Association of Korea (CAK).

Table II : Decommissioning work field associated with the Government Labor Cost

Work Filed	Job Family	Labor Cost
GD	Major in Nuclear Plant	₩194,339
GE	Nuclear Welder	₩189,944
RP	Major in Nuclear Plant	₩194,339
WM	Major in Nuclear Plant	₩194,339
QC	Nuclear Quality Manager	₩228,353
SE	Major in Nuclear Plant	₩194,339
CO	Major in Nuclear Plant	₩194,339

Table II is associated a table with labor costs between the decommissioning work field and the announced

government labor cost on webpage of the CAK in the first half, 2015 [2].

$$TC = \sum UPF\ t \times TW \times Lc \quad (1)$$

- TC = total unit cost of WBS Code
- UPF it = Unit Productivity Factor of item for the work field(man-hour / m^2, m^3, kg)
- TW = total weight of WBS Code (kg)
- Lc = labor cost (cost / hour)

Equations (1) is derived for calculation of the decommissioning unit cost. Calculation procedure start to multiply total weight of the decommissioning targeted facility and the unit productivity factor about each work field. Next, each value of results multiply government labor cost per hour, then is calculated the unit cost factor. Especially, the government labor cost use to divide on eight hour for using the equations (1) because the government labor cost be made by basis on one day eight hour.

Table III : A calculated table for decommissioning unit cost of the K2-9.3

Total weight of K2-9.3 : 15,340kg(ⓑ)

Work Field	Unit Productivity Factor		Cost/Unit(₩)
	m-h/kg(ⓐ)	m-h(ⓐXⓑ)	
GD	0.0137	210.158	₩ 5,105,237
GE	0.0001	1.534	₩ 36,422
RP	0.0057	87.438	₩ 2,124,077
WM	0.0015	23.01	₩ 558,968
QC	0.0021	32.214	₩ 919,520
SE	0	0	₩ -
CO	0	0	₩ -
SUM	0.0231	354.354	₩ 8,744,223

Table III be made by the calculation equations of (1). According to Table III, the K2-9.3 consumed on total 354.354m-h. If government labor cost multiply at this value then calculated values of the Cost/Unit. Specially, Table III show that the K2-9.3 spent most a lot of cost when working for the GD and RP is the second.

2.2 Example of calculation for decommissioning unit cost in Japan and The United States

The Japan Atomic Energy Research Institute (JAERI) have developed the Code System for Management of Reactor Decommissioning (COSMARD) using the data of dismantling in the Japan Power Demonstration Reactor (JPDR) [3].

In this paper, classify three level of the unit cost factor for using the dismantling work data of the JAEA more efficiently. For this reason, assigned to uniformed code system and built in database.

Table IV : The unit cost factor for the heat exchanger in the JPDR

Level	Code	Unit Cost Factor	Mh/Kg
1	JB	General Dismantling	•
2	2040	Heat Exchanger	•
3	L1	1M3 Vehicle, Bio Shield for HE, S hutdown of HE, Feedwater Heater, Fuel fool of HE	0.026

Table IV is an example of the unit cost factor of dismantling in heat exchanger.

The United States have more the decommissioning experience in the NPP for other country. The Vermont Yankee Nuclear Power Station (VYNPS) described relatively detail the unit cost factor and development methodology in the reports. So, we selected the VYNPS among other the dismantled NPP [4]. The VYNPS targeted on Power Block Structures When developing the unit cost factor. As well as, considered to estimate using Labor Cost per Work Duration, Difficulty Factor, and Equipment & Consumables Costs.

Table V : The unit cost factor for the heat exchanger in the VYNPS

Unit Cost Factor	Cost/Unit
Removal of clean heat exchanger <3000 pound	$1,528.53
Removal of clean heat exchanger >3000 pound	$3,835.76
Removal of contaminated heat exchanger <3000 pound	$3,414.57
Removal of contaminated heat exchanger >3000 pound	$9,912.93

The unit cost factors of Table V extracted from the unit cost factor of the heat exchanger in the report. And the Cost/Unit of the table informed to differ depending on size of structure or assessment of contamination.

2.3 An example for a matching table between decommissioning facility of the NPP and decommissioning facility in and outside country

Such a Table VI, built in database for matching of similar facilities between the facilities of the NPP and dismantled nuclear facilities in overseas country.

Table VI : The unit cost and factor for the Heat Exchanger in the each country

Classification	Unit Cost Factor of The Heat Exchanger		
Target	KRR-2	JPDR	VYNPS
Weight	15,340kg	•	>3000 pound
UPF	0.0231m-h/kg	0.026m-h/kg	•
Cost/Unit	₩8,744,223	•	₩11,157,002.72

As shown in Table VI, there is no data for the unit cost factor or weight of structure in each country. Therefore, it has difficult to compare with data of KRR-2 and oversea country. Like this, each country have been calculated on the difference ways about calculating the decommissioning cost. This means need to uniform of the calculation for decommissioning cost.

In this paper, solve these problems using a point of various decommissioning information factors in the KRR-2. In particular, the decommissioning information factors of the KRR-2 provide the unit productivity factor or specification of dismantled facility. This means that the decommissioning unit cost can calculate in various aspects using the decommissioning information factors. If various decommissioning information factors of the KRR-2 reconcile with the using calculation methods for decommissioning cost in other country then actual the decommissioning cost of the NPP will be able to estimate. So, collected decommissioning experience information make possible to predict decommissioning cost of facility such as the NPP.

2.4 An application program for calculation of the decommissioning unit cost

The methods for calculation about one of the WBS Codes looked at in the previous section. In this section, calculate the decommissioning unit cost in the heat exchanger of the NPP using calculation program for the decommissioning unit cost.

$$AVG\ ucf = \frac{UCF(Domestic\ Data + 3rd\ Nations)}{UWI} \quad (2)$$

- AVG ucf = Average Unit Cost Factor (man-hour/kg)
- UWI = Unit Work Items
- UCF = Unit Cost Factors on results of each project
- Other Nations : Decommissioning Experience Data of the JPDR and the Vermont Yankee

Equations (2) is derived for using as a possible indicator to estimate the decommissioning cost about the NPP. In brief, the calculating program for the decommissioning unit cost be used to figure out how much the decommissioning unit cost in facilities of the NPP by calculating average value of the unit cost factor in the each country such as the United States and Japan.

Figure. 1 is a screen about a developed application program for calculating the decommissioning unit cost based on equation (2). The tree of the left side on the program is listed facilities of the NPP. Shown bar chart of bottom of the program is presented one of the unit cost factor after selecting the Facility Code of the NPP. This bar charts is drawn if save the unit cost factor in the each country. Also, horizontal blue line across the bar chart is displayed average value of the each unit cost factor. The average value of the unit cost factor is informed that the unit cost factor or the decommissioning unit cost enter into the facilities of the NPP on average.

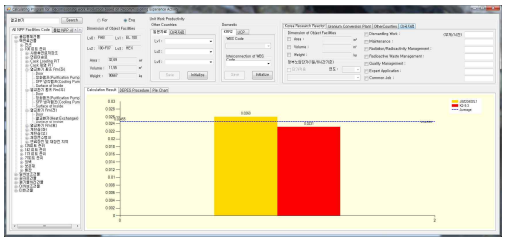

Figure. 1. An application program for calculation of the decommissioning unit cost

3. Conclusions

Korea undergoing difficulty to calculation for decommissioning cost about dismantling the NPP because of there is no experience to dismantling the NPP in Korea. In this paper, but, be used to the specification or the unit productivity factor of the already dismantled KRR-2. It possible to predict actual the decommissioning cost of the NPP comparing with the decommissioning information factor of the KRR-2 and methods of calculation for decommissioning cost in the each country. The decommissioning information of another country makes possible to predict the more precise prediction about the decommissioning unit cost. But still, there are many differences on calculation for the decommissioning unit cost in domestic and foreign country. Typically, it is difficult to compare with data because published not detailed reports. Therefore, field of estimation for decommissioning cost have to use a unified framework in order to the decommissioning cost be provided to exact of the decommissioning cost.

In future studies continually adding in database through review of the collected data and the data about decommissioning experience. So, these efforts will be retained into the accuracy for the calculation of the decommissioning unit cost.

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