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The pretreatment cost of a pyroprocess facility in Korea

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1. Introduction

Since 2011, Russia and the U.S are considering power generation by utilizing shale gas that can be produced at their nations because it is estimated that the price of shale gas would be lower than that of other raw materials needed for power generation. However, some are voicing out their opinion that the power generation with shale gas lacks economic viability compared to the generation with fossil fuel due to the recent decrease in oil price. Shale gas still has many disadvantages such as significant technological difficulties and high costs even when the fracking technology is used to extract shale gas since shale gas is dispersed widely. Moreover, it is estimated that the shale gas can be used for about 60 years, which is comparable to the period estimated for oil deposits [1]. Another concern is that the climate may change due to the discharge of harmful gas produced during the gas extraction process. In particular, question over economic viability has been raising from 2014 since the nations having shale gas do not have the facility and infra for supplying shale gas [2]. Accordingly, nuclear power is perceived as a very promising power generation technology still today by the emerging economic powerhouses such as China and other nations.

2. Methods and Results

2.1 Cost Estimation Model

Process costing method that can estimate each pyroprocess' unit cost is an accounting method that can draw out key cost driver of the pyroprocess in a rational manner. At the same time, it is a very effective cost calculation method that can mix the advantages of the engineering cost estimation method. In particular, raw material cost, labor cost and others used by this paper are real costs that are generated in the PRIDE (PyRoprocess Integrated inactive DEmonstration facility). Thus, accuracy level of the calculation result is very high compared to the engineering cost estimation method.

Process costing method can be utilized in the pyroprocess facility. This is the cost calculation method that is suitable for the process for producing uranium ingot products of considerable quantities. Technology areas that can apply the process costing method include chemical, oil refinery and electronic industries.

Process costing method classifies into the finished product cost of the product that already underwent production process and cost of the WIP(Work-In Process) that is still in the production by adding up the initial WIP and the cost incurred during the current term production process in order to allocate cost incurred during continuous process to the finished products. Accordingly, pyroprocess cost is classified into the raw material and conversion costs as shown on Equation (1). Conversion cost is classified into the labor and indirect costs once again as shown on Equation (2) [3]. Thus, it is possible to classify initial WIP cost including raw material cost with the weighted average method and First-In First-Out method according to the method of distributing ending WIP cost when it comes to the finished product cost. In other words, weighted average method does not distinguish the initial WIP's cost with the cost incurred in the current term, and mixed weighted average value is distributed by dividing to the finished product cost and Ending WIP cost. Meanwhile, First-In, First Out distributes initial WIP cost to the finished product cost in entirely, first and foremost, separate from the current term's cost. This is because it is assumed that the initial WIP is processed before the volume of input in the current term. Accordingly, initial WIP cost is allocated to the finished product cost only, and current term's cost is allocated by dividing into the finished product cost and ending WIP cost.

$$TC = \sum_t \sum_i Mc_i(t) + \sum_t \sum_j Cc_j(t) \qquad (1)$$

Where TC=total cost of pyroprocess, t=time, Mci=the raw material cost of the i-th process at time t, Ccj=the conversion cost of the j-th process at time t.

$$\sum_t \sum_j Cc_j(t) = \sum_t \sum_j Lc_j(t) + \sum_t \sum_j Ic_j(t) \qquad (2)$$

Where Lcj=the labor cost of the j-th process at time t, Icj= the indirect cost of the j-th process at time t

The initial WIP's equivalent units of production and the initial WIP's completeness level can be used to calculate the quantity of production as shown on Equation (3). Ending WIP's equivalent units of production can be calculated by using ending WIP's completeness level as shown on Equation (4). Accordingly, equivalent units of production for the entire volume can be expressed as shown on Equation (5) [4].

$$Q_j^{FWIP} = I_j^{WIP}(t) \times DOC_j^I \qquad (3)$$

Where Q_j^{FWIP} = Quantity of the finished WIP(Work-In-Process) for the j-th process, I_j^{WIP} = Quantity of the initial WIP for the j-th process at time t, DOC_j^I =the degree of initial WIP completion

$$Q_j^{EWIP} = WIP_j^{Ending}(t) \times DOC_j^E \qquad (4)$$

Where Q_j^{EWIP} = Quantity of the ending WIP for the j-th process, WIP_j^{Ending} = the ending WIP for the j-th process at time t, DOC_j^E =the degree of ending WIP completion

$$EUP_j = Q_j^{IWIP} + Q_j^{FWIP} + Q_j^{EWIP} \qquad (5)$$

Where EUP_j = the equivalent units of production for the j-th process, Q_j^{IWIP} =Quanity of the initial WIP for the j-th process, Q_j^{FCWIP} = Quanity of the finished current WIP for the j-th process, Q_j^{EWIP} = Quanity of the the ending WIP

2.2 Cost Estimation Results

Since each unit process' handling speed is different in actuality from the facility's operation aspect, Work-In Process storage facility playing the role of a so called buffer that can store Work-In Process temporarily before Work-In Process(WIP) gets transferred to the next process is needed. If this type of facility racks, bottleneck phenomenon is generated in the material flow, and very inefficient amount for processing is generated since some process devices cannot be operated. Accordingly, the process system is required to handle Work-In Process most effectively through process simulation.

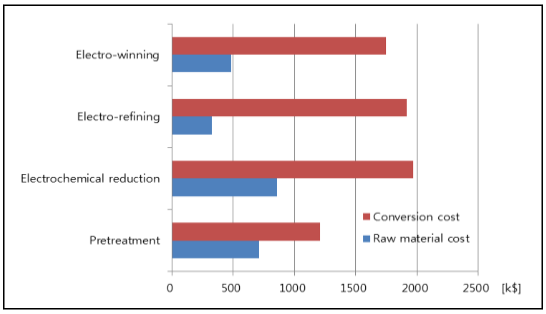

Figure 1. Raw material costs and conversion costs(annual basis)

Figure 1 shows the result of calculating the raw material and conversion costs (labor cost included) by each unit process by utilizing First-In, First Out's process costing methods. As a result, raw material cost was calculated as $107/kgHM in the electrochemical reduction process as shown on Table 1 while conversion cost was calculated as $203/kgHM, proving that most cost is incurred among the pyroprocesses, followed by electro-winning process with raw material cost of $54/kgHM and conversion cost of $177/kgHM. The reason why the cost of the electrochemical reduction cost takes up too much is owing to raw material cost of the Platinum, which is used as anode electrode is very expensive with $54,000/kg. Thus, Platinum's raw material cost was manifested as the key cost driver of the electrochemical reduction process.

Table 1. Unit costs for each process

Category	Process cost	
Process name	Raw material cost	Conversion cost
Pretreatment	71	124
Electrochemical reduction	107	203
Electrorefining	36	179
Electrowinning	54	177
Total	268	683

3. Conclusions

PRIDE facility producing 10 ton/year uranium ingot was set as the cost object for the cost estimation, and it was possible to increase cost calculation's accuracy level since labor cost and expenses incurred in this facility were the costs incurred in actuality. In the end, First-In, First Out process costing method was used to calculate the pretreatment cost of pyroprocess. According to the cost calculation results, the pretreatment cost was estimated as $195/kgHM and the cost share of the pretreatment of pyroprocess was calculated as 20%. Accordingly, electrochemical reduction process is the process requires most cost, followed by the cost of electro-winning process. Moreover, it was disclosed that the difference between electro-refining and electro-winning is not very significant from the cost share aspect, and it was calculated that the pretreatment unit process consumes the smallest cost among pyroprocess costs.

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