Analysis of Recent Patent Trend of Vitrification Technology for D&D

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1. Introduction

Low Level Waste (LLW) shall be transferred to and disposed at KORAD after the solidification process treatment. Vitrification as one of solidification processes can be adopted to LLW targeting the final disposal of Kori #1 LLW because of much merits such as more safety, integrity, volume reduction efficiency, etc. than other solidification processes. In Korea, KHNP has developed the vitrification technology and plans to export the technology to USA, Japan, etc. with much preliminary R&D achievements [1] as well as to adopt it in D&D project towards Kori #1. For the expanding of acceptability of vitrification technology, this paper shows the recent patent trend and presents useful acceptability of the technologies registrated as patent towards D&D project targeting Kori #1 LLW whose decommissioning is expected to start in 2022.

2. Patent Trend and Acceptability

For the patent trend analysis Korean patents are investigated based on vitrification terminology from patent information searching service site (KIPRIS) [2].

2.1 NO. of patents

In KIPRIS total 78 patents were recorded. The status of applied patents is shown in Table 1. Applied patents were divided by registration (still effective in patent effectiveness point of view), discharge, withdrawal, reject, abandon and public opening..

Table 1. Status of patents in KIPRIS

Division	No. of patent
Registration	50
Discharge	13
Withdrawal	2
Reject	8
Abandon	2
Public Opening	3
Total	78

2.2 Status of patent registration companies

Among total 78 patents, 50 patents were registrated by the companies which participate or plan LLW treatment work as shown in Table 2

Table 2. Status of companies on registration

Company	Type of company	Registration year
KEPCO	Public Organization	2000(3 patents)
KHNP	Public Organization	2002(1) 2004(1) 2008(1) 2010(2) 2011(4) 2012(6) 2013(4) 2014(1) 2015(2) 2016(1)
KIRAM	Public Organization	2006(1)
SNU	Public Organization	2013(1)
World Tech	Private company	2011(1)
Commisaria	Private company	2000(1) 2003(2) 2009(1)
Energy Solution	Private company	2008(1)
Mr. Nam	Individual	2010(1)
KAERI	Public Organization	2007(1) 2009(1) 2012(1) 2014(1)
HYU	Private University	2013(1)
Areva NC	Public company	2009(4)
ENT	Private company	2015(4)
Societe General	Private company	1999(2)

2. 3 Titles of patents

KHNP developed vitrification technology towards Uljin nuclear power plant (NPP) as shown in Fig. 1. This system consists of Glass Frit Feeder, Waste Feeder,

Resin Feeder, Filters (High Temp./Carbon/HEPA), Post Combustion Chamber, Off-gas cooler, Extraction Fan, Cold Crucible Melter, Scrubber, Reheaters (A & B), Dust Recycle System, deNOx system, etc. Especially this system fully considers the environment aspects by installing DeNOx system, Acid Gas removal system, Dust collection system and dioxine dissolution system.

As referred in Figure 1 the titles of patents are much related to KHNP's vitrification system in the field of start-up method, vitrification process, measuring equipments & technologies, vitrification composition, confinement method, mitigation of phase formation, glass formulation, etc. And on the other hand, the vitrification method, waste treatment system and criticality control method, etc. are presented as main titles of patents by domestic and foreign companies as shown in Table 2. Main titles of patents are "Method of start-up of glass using resistance heater in crucible melter combustible low and intermediate level radioactive waste" (KEPCO), "Vitrification equipment and processes for low and intermediate level radioactive from nuclear power plants" (KHNP), "Method for vitrifying low and intermediate level radioactive waste using iron-phosphate glass" (KIRAM), "Method for vitrifying radioactive rare earth waste" (KHNP), " Method for vitrifying radioactive rare earth waste" (SNU), "Low and intermediate level waste treatment system" (KEPCO), "Vitrification compositions and vitrification method of low level radioactive wastes" (KHNP), and "Vitrification compositions and vitrification method of mixing wastes" (KHNP). The foreign companies such as Energy solution, Areva NC, Commisaria and Societe General also registerated the patents for Korean market participation in the future. These companies patent titles are "Mitigation of secondary phase formation during waste vitrification", "Alumino-borosilicate glass for confining liquid effluents and method for processing radioactive effluents", "Process for waste confinement by vitrification in metal can", and "Method and device for incineration and vitrification of waste, in particular radioactive waste" respectively.

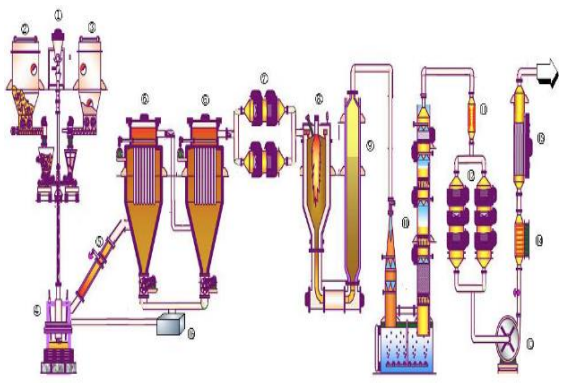

Fig. 1. Vitrification System installed at Uljin NPP

2. 4 Acceptability to D&D projects

As published in public in newspapers in 2017, KHNP proposed R&D for vitrification to Japanese government towards LLW, etc. generated from Fukushima NPP and proceeded the cooperation with IHI [3]. This means the vitrification technology can be adopted to D&D towards Kori #1 for LLW. KHNP's vitrification technology can treat both combustible wastes with low temperature melting system and also treat non-combustible wastes with plasma torch system. The combination of these two systems can contribute the full satisfactory waste reduction of LLW generated in Kori #1 during decommissioning comparing to other country's vitrification technologies [4]&[5].

3. Conclusions

50 patents are registrated by 13 entities for vitrification technology. Especially KHNP, the owner of Kori #1, whose decommissioning is expected in 2022 after the approval of termination plan by KINS, has much registrated the patents and achieved the technology development for vitrification acceptability towards D&D projects. And the other companies which want to participate in D&D also contribute the vitrification technology development so far. 50 patents registrated in KIPRIS can contribute to D&D project towards Kori #1 if the characteristics LLW at Kori #1 is clarified and investigated and the merits of each vitrification technology is appealed during the decommissioning of Kori #1. Especially, KHNP's technology is approved as the most useful vitrification technology towards D&D projects for LLW, so it is necessary to merge patent technologies around KHNP's technology if necessary. And KHNP's efforts to help the patent registration companies is also required before the start of Kori #1 decommissioning. Based on the experience and upgrade through vitrification technology application at Kori #1 in near future, the patent registration companies around KHNP are expected to enter the world D&D market easily and efficiently with the sole and unique vitrification technology toward LLW generated at D&D sites.

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