A study of overseas research activities for thorium reactors and the need for the introduction of the domestic nuclear power

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1. Introduction

The safety issues of Nuclear Power Plant more increased due to the accident of Japan's Fukushima Nuclear Power Plant. Apparently, it was caused by natural disasters but in terms of physical point, it failed to remove ensuing decay heat. The decay heat of the reactor melted core and the zirconium is to reach a hydrogen explosion in the process of

$$Zr + {}_2H_2O \rightarrow ZrO_2 + {}_2H_2$$

The decay heat up to 7.5% of operating power by the radioactive decay of fission products after shut down is one of elements to threat safety of Nuclear Power Plant that using Uranium fuel. But if use Thorium as nuclear fuel, it is not able to generate Neutrons because of it is not spontaneous fissile nuclide so stop the fission automatically and can be avoided major accidents. Many countries have been proceeding research actively in this area as highlighted these advantages but de facto, there are not official research activities in Korea.
This paper is to analyze the current status of research in some countries and describe the possibilities introduce with necessity in Korea.

2. Oversea research status

Overseas researches well-known through media report. U.S Argon, Oak Ridge National Laboratory, Chinese Academy of sciences, Belgium with European Union, Brazil, Japan has formulated plan for construction or actual construction or under study. The main core on thorium research is how to generate Neutrons and how to operate with a subcritical state according to the bellow formula.

$$M=n/1-k_{eff}.$$

M: generated total neutrons.
n : injected neutrons
k_{eff} : the effective multiplication factor.

Circulation Map for the generation of the basic neutron get artificial radionuclide $U\text{-}_{233}$ through decay process and to make virtuous cycle of conflict, generate through fission.

$$Th\text{-}_{232} \rightarrow Th\text{-}_{233} \rightarrow Pa\text{-}_{233} \rightarrow U\text{-}_{233}$$

In addition to these problems, the countries that research for thorium reactor has approximately 5 joint projects as bellow.

1. The design of nuclear reactor to use thorium as fuel efficiently.
2. Technology on the distribution and processing of the fuel.
3. Spend fuel reprocessing technology.
4. The issues for economics of the fuel cycle
5. Proof of the losses and profits.

It seems worth to solve the challenges listed above if look at the profiles shown in Table 1, compared with the thorium and other fuels.

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Table 1: The consumption of fuel and features based on power production annual 1GW

Coal	Uranium	Thorium
3,500,000t	200t	1t
Environmental hazards according to the occurrence of large amounts of CO_2.	Low-carbon, however, the threat of proliferation of nuclear weapons through reprocessing.	Consume plutonium and radioactive waste.
	Long-term storage of hazardous waste.	Reduction hazardous factor due to reduce waste.

Based on these advantages, around the world including the United States, China, Norway, Japan, and India doing research and development for thorium reactor competitively as well as recently the British scientists announced that they developed new device that can be incinerated TRU waste in thorium reactor.

3. Our status for thorium reactor and introduction of methods

Korea has not any plan de facto for the development on thorium reactors at this moment.
Some of scholars interested in design research for future core of reactor thorium-based but national support is

desperately needed due to the enormous cost.
And our nuclear power plant operators may be reluctant to support the development of the thorium reactor research because the cost that used for development of advanced technologies for existing uranium reactor can be buried like the case of foreign. However, as mentioned above, the situation in the world participates competitively in new reactor using new fuel so and we must begin the research under the conditions we have now.
Fortunately we have a plan few of new nuclear power plant construction is expected to continue so can start the research with prepare only the construction of infrastructure and basic facilities for thorium reactor study at the place of construction expected and part of artificial neutron irradiation on thorium nuclear fuel, Korea already possesses proton accelerator using neutron mass production techniques. So and can continue research for proton accelerator available practical part.

4. Conclusions

Radiation and the radioactive waste, decay heat, loss of coolant accident that related with safety issue are always emerging as a problem of social acceptance of nuclear power plant. Proportion of $U\text{-}_{235}$, uranium fuel is only 3-5% and the rest of $U\text{-}_{238}$ is discarded as all nuclear waste in accordance with “Open Cycle”. Even if put to practical use thorium reactor, nuclear waste generated but can significantly reduce the toxicity nuclides of TRU and not only the decay heat that physical cause of Fukushima nuclear power plant accident does not occur but also do not need to worry about the LOCA.

Our nuclear power plant have been operated very safety compared to Japan. Relative to unexpected operation stop status in terms of base 5years previous of Fukushima nuclear accident are 0.5 based on average value in our nuclear power plants on the other hand 0.4 in total 17 units of nuclear power plant subsidiary Tokyo Electric Power co., Japan. It is similar to ours, and is similar to Kansai Electric Power Co. However, total reported incidents of non-severe accidents are much higher than ours. But that cannot be interpreted as the safety of our operating skills of nuclear power plant are excellent compared to other countries.

For many people’s anxiety about nuclear power plants operating after the Fukushima accident, nuclear operators emphasized the safety of our nuclear power plant with referring to the difference between PWR and BWR. Our nuclear power plant were complementary in many facilities depend on problems revealed at the Fukushima nuclear power plant. But it seems to be need for long-term research and development of next-generation nuclear power plant that safety is certainly collateral such as thorium reactor.

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