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A newly developed accelerator to convert thorium to uranium-233

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For constructing a sustainable society, low-carbon energy sources and low-carbon automobiles are required. In addition to the use of nuclear power, renewable energy such as wind-mills and solar power are used as low-carbon energy sources. Electric vehicles (EV) and hybrid vehicles (HV) are expected to be used as low-carbon automobiles. An essential raw material in order to fabricate these machineries is rare-earth elements (REE). In recent years, the rare-earth supply has been unstable due to China's monopoly in its production. China's monopoly of rare-earth production was caused by loss of market competitiveness of other countries that needed to expend cost for taking care of thorium which occurred as by-product of rare-earth refining. Thorium can be used as nuclear fuel but thorium is merely fertile. Therefore, additional supply of fissile material is necessary to utilize thorium. As a result, currently there are no countries that separate and store thorium as valuable except India.

The authors have studied (1) molten-salt reactor (MSR) as a utilizing technology of thorium, (2) implementation capacity of thorium MSR supported by a supply of plutonium from spent uranium fuel and (3) international framework to protect the environment from thorium which occurs as by-product of rare-earth refining. The available implementation capacity of thorium MSR by using all plutonium based on the prediction of IEA's uranium fuel cycle is only 392 GW at 2050. This capacity of thorium MSR requires 76 thousand tons of thorium but total amount of thorium occurring as by-product of rare-earth reaches to 444 thousand tons. If there is no use of thorium, it might be abandoned to the environment illegally.

The authors are considering a new framework to protect environment by giving an incentive of storing thorium by adding value to excess thorium. A newly developed accelerator neutron source is a method to add value to thorium. Spallation reaction has been known as neutron source which uses high-energy acceleration. The author adopts a low-energy and high-intensity accelerator to use D-Be reaction. This is named as "TRANS (Tandem Repeat Accelerator Neutron Source)". TRANS can operate multiple accelerator-tubes in parallel to increase neutron yield. The maximum neutron yield of TRANS-2012 (Acceleration energy is 2 MeV) is 5x10 14 n/s.

In this paper, concept of TRANS is described and its applications such as thorium-fuel production, accelerator driven sub-critical system (ADS) will be introduced.

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