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Nuclear Fission in Fast Breeder Reactors and Its Sustainability

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Abstract. This study analyzes the feasibility and sustainability of nuclear fission fast breeder reactors from the perspective of energy utilization. Through the analysis of the principle of nuclear fission, and the analysis of nuclear material reserves and energy efficiency. And compared with ordinary thermal power plants. We found that the reactor has a great advantage of sustainable development .It is worth further development.

Introduction

Based on the fission principle, fast breeder reactor generates fissile material from stable materials, like uranium-238 and thorium-232, and produces large amount of energy due to high-energy interactions among atoms.[1]

Nuclear Fission Principle

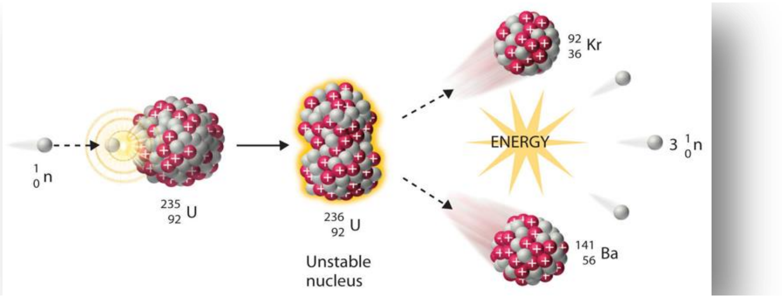

Figure 1: Diagram of atomic fission

Example of U-235 Fission (shown in figure 1):
First step: U-235 absorbs a neutron and then turns into an excited U-236
Second step: The excited U-236 splits into fast moving light elements (fission product), and the energy and three free neutrons are released in this process.
Third step: Those free neutrons trigger more fission reactions.

Sustainability

In the early development of nuclear fission reactors, the principle of breeding reactors had been recognized. The world's first fast neutron reactor was built in the USA in 1946. In others countries like UK and the Soviet Union, this technology started in the early fifties. These first-generation breeder reactors are mainly used for studies of fast neutron physics. Also, they were used the confirmed the technical solutions are adopted. Due to the high power per unit volume in the core, liquid metals such as mercury or sodium were used for coolant. [2]

Breeders produce much more plutonium, which can be reused as fuel. So the fast breeder reactor mainly includes two resources—uranium and plutonium. The world's present measured resources of uranium (5.9 Mt) around 1.5 times offered spot prices which used only in conventional reactors are enough to last for at least 90 years. [3]This represents a higher level of guaranteed resources than is normal for most minerals. Further exploration and higher prices will certainly, by present geological knowledge, yield further resources as present ones are used up. Plutonium is formed by the neutron

capture of uranium -238 nuclear reactors when the operation of a typical 1000 MW nuclear reactor in the uranium fuel load of several hundred kilograms of plutonium.[4]
Two broad categories based of nuclear plant can be decided upon their neutron spectrum. The comparison is shown below in the Table 1.

Table 1: Comparison between Fast breeder reactor and Thermal breeder reactor

	Fast Breeder Reactor	Thermal Breeder Reactor
Types of Neutron	Fast neutrons	Slow neutrons
kinetic Energy of Neutron	1 MeV	0.025 eV
Fission fuel	both the U-235 and U-238	U-235
Waste	short-lived fission short-lived fission product	long-lived transuranics and short-lived fission product
Fuel efficiency	extract almost all energy in atom	less than 1% of uranium

Like all other heavy elements, plutonium has some isotopes, the difference in the number of nuclei. All 15 plutonium isotopes are radioactive because they are unstable to some extent, and, therefore, decay, emit particles and some gamma radiation as they do so.

All of the plutonium isotopes fission neutron fission, although only two (slow neutrons). Therefore, it is important in the fast neutron reactor, but only one (FNR) - the main role of plutonium 239 - in conventional light water reactors. Each fission yield over 200 MeV, or about 82 MJ / kg.

The most common form of plutonium isotopes in a typical nuclear fission plutonium 239, generated by U-238 neutron capture (followed by beta decay), and wand which when fissioned yields much the same energy as the fission of U-235. [5]U-235 fission in the reactor core to produce plutonium, half is "burned" in situ, is the total heat output of light water reactors responsible for about 1/3 of the (LWR) and the temperature of about 60% pressurized heavy water reactor (CANDU) such as CANDU. In LWR rest, about 1/3 by neutron capture into Pu-240 (and Pu-241). In a fast breeder reactor, this proportion is much less

In a fast breeder reactor, uranium can be used 60 times more efficiently, burn all the uranium -238U and 235U (in contrast to The once-through reactors, which burn mainly 235U). As long as we don't throw away the waste fuel, spit out a reactor, this source of depleted uranium too, so the uranium put in once through the reactor does not need to lose.[6] Uranium (plus depleted uranium reserves) is 60 times more efficient than the fast breeder reactor, which will power up to 33 kWh per person per day.

There is a consensus view on the criteria that must guide nuclear fission sustainability. They are the following ones:

•Non-proliferation (proliferation resistant technologies and materials).

•Operational safety of nuclear installations, particularly NPP, in order to minimize accident probability and radioactivity releases. In particular, attention should be given to reducing, as much as possible, the radioactive inventory released in any accident.

•Minimization of nuclear waste radio-toxicity (particularly in the very long term, i.e. beyond the standard time scale of human history).

•Efficient use of nuclear fission raw materials (which are very poorly served by current nuclear fuel cycles).[7]

Environmental Impact

Since fission reactions create unique and unconventional waste, the methods of ensuring a low environmental impact differ greatly from that of conventional fossil fuels. There are specific advantages and disadvantages to the nonconventional waste of nuclear fission, all of which must be addressed for efficient and safe nuclear power.[8]

Figure 2: Permanent storage barrels for high-level waste

There have been numerous attempts to store or dispose of waste, which included reprocessing waste into useful materials or diluting waste to radiological levels of seawater. Recently however, the increasing concern for safety has made many of these methods unusable by law. [9]The proposal for a large-scale and permanent storage facility at Yucca Mountain, Nevada had been established in the early 1980s, but was never put into place. The facility was to be a large repository for spent fuel and other high-level waste by-products deep underground, presumably to support the United States' nuclear waste needs. The resistance to the project by the local populace, lack of funding, poor economic feasibility, and political opposition in Nevada caused the plans to be abandoned in 2011. [10]Since the failure of the Yucca Mountain facility, there have been no other proposals for permanent storage in the United States.

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