One that is used to start and organize

Design

One of thenuclear reactions is called nuclear fission. Nuclear fission is basically areaction that happens when a nucleus of a massive atom is divided into a fewlighter parts (usually two parts, often called binary fission) when thismassive nucleus is hit by a particle such as a neutron. That procedure producesfree neutrons and a huge amount of energy (Santics, Monti and Ripani, 2016).

In1938, Hahn and Strabmann unexpectedly discovered nuclear fission in the Germancapital city, Berlin (Krappe and Pomorski, 2012). A nuclearfission reaction cannot take place without four main components: 1- Reactor: to take place a nuclear fissionreaction requires a reactor which is a device that is used to start andorganize a nuclear reaction. There are many different types of nuclearreactors. Some of these reactors are Magnox, AGR, PWR, BWR, CANDU and RBMK. Inthe UK, AGR and PWR are mainly used to generate power (Nuclear Reactor Types, 2005).

The UK has 15 reactors generating about 21% of itselectricity but almost half of this capacity is to be retired by 2025. These reactors are usually called thermal reactors because they utiliseslow or thermal neutrons. There is also a different type of reactors that iscalled fast-neutron reactor or simply fast reactor which uses originally fastneutrons to initiate the fission chain reaction (Nuclear Reactor Types, 2005). 2- Moderator: a moderator is substance that is utilised to slow down the neutrons released infission, therefore, that would lead to produce more fissions. A moderator is acomponent in all thermal reactors but not the fast reactor. (Krappe andPomorski, 2012). 3- Fuel: it consists of substances that are potentially fissile such as 233U, 235U, 239Pu, 241Pu. The fuel is the mediumwhere fission reactions and most of the energy transformation of fission energyinto thermal energy happens.

In general, uranium is the basic fuel in most ofthe operating reactors (Krappe and Pomorski, 2012). 4- Coolant: It is a liquid or gas surrounding the nuclear reactor core used to restrict itstemperature. The coolant could be water, heavy-water, liquid Na, He gas, CO2, liquid Pb or a liquidlead-bismuth eutectic mixture. In water reactors, themoderator works also as coolant (Krappe and Pomorski, 2012). Figure1 is a summary of the different types of thermal reactors with their moderators, fuels and coolants: Figure1: Summary of the Different Types of Thermal Reactors with their Moderators, Fuels and Coolants (Source: Nuclear Electric, 2005) Reactions are implementedin thermal or fast reactors.

The main difference between them is that thermal reactors slow down neutrons asquickly as possible so that less neutrons are wasted to 238U. Toavoid that, a moderator is inserted in the design, some substances with a lightnucleus could absorb a large amount of energy from a neutron in one collision. On the other hand, fast reactors use just the opposite method. They attempt tokeep the neutrons fast with high energies as long as possible (Nuclear Electric, 2005). Fast reactors do not require a moderator to operatebecause a neutron may have high kinetic energy or be a fast neutron, so we usemoderator in thermal reactors to thermalize this fast neutron. Fast neutron hashigh kinetic energy. Fast reactors use 238U as fuel which has a high cross section for fast neutronbut very low cross section for thermal neutron. Therefore, they do not need anymoderator and immediately go into fission reaction with 238U (NuclearElectric, 2005).

Nowadays, thermal reactors play a major role commercially as they are reactor systemsthat use slow or thermal neutrons to initiate the fission reaction in the 235U fuel. Evenwith the different enrichment levels used in the fuel in these reactors, yet, large numbers of atoms present are 238U, which cannot be split. Therefore, when an additional neutron is absorbed by theseatoms, their nuclei do not divide but are transformed into another substance, Plutonium. Plutonium is fissile and some of it is consumed, and some of thisplutonium is left with 235U that was not utilised (Nuclear Electric, 2005). After that, these fissile elements can be takenfrom the fission reaction wastes.

Then, they can be recycled. Therefore, thatwould diminish the usage of uranium in thermal reactors by 40 percent, eventhough thermal reactors still need a huge stock of natural uranium. However, it is possible to design a reactor which sufficiently produces more fissile substancesthan it consumes. This is the fast reactor in which a moderator is notneeded. Fast reactors, however, are now still at the preparation stage (NuclearElectric, 2005).

Fast reactors are extremely expensive to buildthan other types of nuclear reactors and will therefore become economicallybeneficial only if uranium prices noticeably go up. To sum up, the great improvement of fast reactors has dramaticeffect in principle. This is because they have the potential to increment theenergy available from a specific amount of uranium by a factor of 15 or evenmore, and can utilise the existing quantities of used uranium, which would haveno benefit if it is not used (Santics, Montiand Ripani, 2016). Since fast reactors, theunmoderated reactors, produce more energy than thermal reactors, fast reactorsare preferred to be built even it is expensive if we look at this situation inthe long-term.