How does a nuclear reactor operate?

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The nuclear reactor is the unit that produces controlled chain fission reaction. When uranium nuclei split, nuclear energy is turned into kinetic energy carried by fragments of nuclei. The splitting process is accompanied by the release of neutrons. Products of fission – “nuclei fragments” – are moving at a very high speed. Slowing them down in the substance of a fuel pellet converts their kinetic energy into heat energy that heats fuel. In nature the process takes place rarely, because natural uranium has a low level of radioactivity - fuel pellets from the factory can be safely held in bare hands!

To produce power of 3000 MW the reactor has to sustain 1020 (one hundred billion billions) instances of fission in 1 second. How can this be achieved? It turns out that uranium nuclei (in particular the isotope uranium-235) split when bombarded by neutrons. As the splitting of each nucleus of uranium-235 produces two to three neutrons, which in turn cause fission of other nuclei, under certain conditions one can manage the process when a continuous controlled chain reaction involving a huge number of nuclei releases enormous thermal energy. The temperature inside fuel pellets of the operating reactor may reach two thousand degrees!

The reactor is designed to remit this energy to another substance, which is called the coolant. Water is used as a coolant in most cases, in the fast-neutron reactors liquid metals are used.

The energy of neutrons at the moment of their release in the reactor is enormous: they move at a speed of several thousand kilometres per second. These are “fast neutrons”. As a result of collision with neighbouring nuclei their energy and speed decrease. This process is called slowing down or moderation of neutrons. Thermal neutrons are most likely to succeed in splitting nuclei of uranium-235, which allows for effective use of fuel with an insignificant concentration of uranium-235. Neutrons are effectively slowed down by water that acts as a coolant in some type of reactors.

Thus, controlled chain fission reaction of splitting nuclei of uranium-235 into parts by capturing slowed down neutrons, which are released during fission, takes place in the nuclear reactor. The fission process produces a huge amount of heat and can be controlled by decreasing the number of secondary neutrons in the reactor.