Nuclear plants

Electronuclear plants

A nuclear power plant allows the production of steam without using fossil fuels. A nuclear reactor behaves like any boiler and the steam it generates can be used to operate a turbine connected to an electricity generator.
In particular, the “heart” of the reactor of a fission nuclear power plant is called “core” and generally has the shape of a cylinder. The core is made of a liquid, for example water, into which cylindrical uranium bars are dipped, a couple of metres long and with a diameter of a few centimetres.
At regular intervals there are control bars capable of absorbing many neutrons. Thus, the chain reaction is kept under control and stopped, if necessary. In the most common type of reactors, the water contained in the core is warmed by the fission of uranium and is circulated by means of a pump until it reaches a heat exchanger, into which it cools down producing steam which, in its turn, rotates the turbine of the plant.
A reactor is classified according to the type of fuel, the type of coolant and the core’s inner architecture. For example, a common distinction is made between light water and heavy water reactors.

Light water reactors

In light water reactors the fuel is made of cylinders of uranium oxide enriched with uranium 235. The water circulates among the cylinders and acts both as a controlling element and as coolant.
The core is hosted in a pressurised steel container provided with the coolant intake and outlet holes. Shields to absorb the nuclear radiation are mounted around the container and the active parts of the reactor: the metal heat shield mainly absorbs gamma radiation, the concrete biological shield absorbs neutrons. Of course the safety and emergency systems necessary to face possible nuclear accidents are paramount.

Heavy water reactors

The fuel of heavy water reactors is made of non-enriched natural uranium. There are more modern reactors called “fast” reactors, cooled by means of liquid metal and working with highly enriched fuel by converting uranium 235 into plutonium. The French Superphenix produces 1200 electric megawatt with a 40% total efficiency. However, such plants show several limitations, including the cost of the energy produced, 2-3 times higher that of a light water power plant.

The past and the future of reactors

Nuclear reactors can be classified into four generations, depending on some common characteristics and depending on the period in which they were designed and built. Currently, 436 reactors, mainly of the first and second generation, and some units of the third generation are operating.
The first generation includes prototypes and reactors for the production of electric power or plutonium for nuclear weapons, designed and built before the 70s. Generally these reactors are characterized by low thermal power which, in the case of commercial power reactors means power generally lower than 300 MWe. In Italy, there are three nuclear power plants (Latina – 210 MWe, Garigliano – 160 MWe and Trino 270 MWe) which we can consider of the first generation. The plants were shut down in 1986 and at present are being dismantled.
The second generation mainly includes light water reactors, built and utilized starting from the 70s and 80s and which are still operating. Generally these reactors are characterized by electric power ranging from 300 MWe to 1000 MWe. In Italy, the nuclear power plant in Caorso (860 MWe) can be considered a second generation reactor even if at present it is shut down and it is being dismantled.
The third generation refers to the advanced type of rectors which derive from the optimization, in terms of economy and safety, of the current light water reactors. Generally, third generation reactors are characterized by electric power over 1000 MWe. Often 3+ generation reactors are also mentioned. These include systems that may be introduced in the next 10-15 years, and therefore much before the fourth generation reactors, and meanwhile, these can also lead to

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advantages in the development of the same.
The fourth generation includes innovative nuclear systems which probably will reach a technical maturity after 2030. These nuclear systems are designed to supply energy in a very competitive manner from an economic point of view, and to extend and improve safety in case of accidents, to minimize radioactive waste, (in particular waste that remains radioactive for a long time), and to promote the rational use of natural resources (with a greater exploitation of fertile and fissile materials), to produce hydrogen directly (without having to pass through the production of electric energy) and to guarantee greater reliability.
Source: Agi Energia

Fusion reactor

The fusion reactor works according to the opposite principle to the fission reactor. The fission reactor divides the nuclei of heavy atoms and the resulting heat is released in order to heat water and activate, through the water vapour, a turbine that produces electricity. Instead in the fusion reactor, light atoms (hydrogen isotopes deuterium and tritium) are united into a helium atom (fusion). The fusion frees a bit more energy than the fission and does not produce any radioactivity.
In the fusion, only if two nuclei are located very close one to the other, the force of nuclear attraction melts them. The problem is that this force only act at very short distances, at thousand billion parts of a millimetre, and as the nuclei that are going to be melted are both positively charged, when they get closer, they tend to push back and do not melt due to another force, i.e. electrostatic repulsion, that acts on bigger distances and hamper the fusion.
In order to break that barrier, the nuclei have to be in excitement state, at more than a hundred million degrees temperature, when atoms are detached from their electron “shell”. This is the condition when the fusion naturally occurs between light atoms.
The extremely high temperature that is needed to fusion plasma (the ionised hot mixture of deuterium and tritium, hydrogen isotopes), i.e. several million degrees, has not allowed to build a fusion reactor at industrial level. Nevertheless, the research is continuing to make important progress and the objective seems to be approaching.