Nuclear Fission: Present and Future*

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An outline of nuclear power plants at world level opens the presentation, addressing also to future programs of major countries. In this context research developments for reactors, nuclear fuels, reprocessing plants, nuclear wastes and repositories, particularly in European Union and USA, are discussed.
Present researches are concentrated in two groups, one at short and medium term for a reactors' generation denoted with III+ and a second one at long term, which means 2030 for commercial start-up, characterized as "Generation IV".
In the first group researches are concentrated on life extension of reactors and on maximising the energy outputs of their fuels, which means the increase of burn-up up to sixty GWd/ton and more.
In USA almost one half of the 103 reactors in operation have been authorized by the control authority NRC to prolong their licences of 20 years, and the remaining ones will follow.
There is an increasing tendency in the world to adopt the closed fuel cycle with reprocessing of exhausted fuel and recovery of uranium and plutonium for their recycling in the form of mixed oxydes fuels.
The problem of wastes is extensively treated for short life and very long life ones.
In European Union these nuclear wastes increase at a rate of 40.000 m^3 per year.The long life wastes, which presently totalize 17.500 t, have an annual production of 1.730 t. The wastes coming from the two reprocessing plants of La Hague in France and Sellafield in U.K. have reached a volume of 6.000 m^3, which increases now at a rate of 240 m^3/year.

Ad hoc researches are performed for the best solutions of surface repositories for low and medium activity wastes of short life and for geological repositories, for long life wastes. The firs ones may serve also for interim storage of long life wastes, which was originally conceived for a period of 50 years of cooling and now, from the results of these researches, seems may be extended up to some centuries, allowing more time for the deployment of geologic repositories, well certified and retrievable for a convenient period. For this type of repositories, in EU, between 1990 and 1995 the Sweden has built in ASPO the Hard Rock Laboratories, a vast complex at 460 m of deepness in granite, a rock whose only 2 m. may block the most penetrating radiations.
In Finland, after a long popular consult, the decision has been taken to site a geologic repository in Holkiluoto. Its construction will start in 2010 and will be completed in 2020.
30 years after, at the light of then available technologies, the decision will be taken if this repository will be, or not, definitive.
To reduce greatly the problem of nuclear wastes an important line of research has been undertaken with a sharp separation , in the reprocessing, of long life radionuclides such as the minor actinides rutenium, cesium and neptunium and a few fission products like I 129 and tecnetium 99.
Once separated, these radionuclides will be irradiated in a fast neutronic spectrum and transmutated in short life nuclides.

* Abstract della relazione alla terza conferenza sul futuro della scienza "The Energy Challenge"- Venezia, 19-22 settembre 2007.

To make this job, we need fast reactors of the fourth generation or special devices called ADS (Accelerated Driven Systems), which consist in a protons accelerator, coupled with a subcritical fast reactor.
The French, in their Atalante experimental plant, have demonstrated the possibility of the separation of the minor actinides and have furtherly irradiated them for transmutation in their Phenix reactor. The whole process, scientifically ascertained, is now developed to evaluate the feasibility of its evolution to an industrial scale.
In European framework Program VI a research program, called EUROTRANS, has been initiated to evaluate experimentally the nuclear transmutation.
Coming to USA, the Department of Energy has devoted an important research program on the nuclear fuel cycle for the short term (Advanced Fuel Cycle Initiative, AFCI I) and the medium term (AFCI II).
With AFCI I the USA re-open the activities on closed nuclear fuel cycle, aiming at a strong reduction of the volume of their nuclear wastes to be inserted in geological repositories.
Up to now they have accumulated 44.000 metric tons of exhausted fuels distributed in all their commercial nuclear reactors, with a production of 2000 tons of exhausted fuel every year. At this rate, the available volume of their geological repository of Yucca Mountain, if finally certified, should be filled in the year 2015.
After September 11 2001, it is obviously much better to concentrate underground the exhausted fuel instead of leaving it in so many dispersed localities. More, if the 440 tons of plutonium in the exhausted fuel might be recovered in a reprocessing plant and recycled in the present american reactors as MOX fuel, all the plants might produce energy for four years and half.
In the meantime in USA an experimental reprocessing technique called Uranium Extraction Technology, UREX, has shown, with tests performed at the Savannah River Technology Centre the ability to recover uranium from the exhausted fuel in the amount of 99,9%.
The American research program, strictly connected with the development of Generation IV reactors has the following tasks:

- to reduce the volume of high activity wastes;
- to increase the capacity of Yukka Mountain repository;
- to reduce the amount of the plutonium in the exhausted fuel;
- to recover energy form the exhausted fuel;

and, for the long term:

- to reduce the radiotoxicity of the exhausted fuel;
- to reduce in it the generation of heat at long term;
- to produce fuel for future Generation IV reactors.

Further researches will be performed at the high flux isotope reactor of the Oak Ridge National Laboratory and the advanced test reactor of the Idaho National Engineering and Environment Laboratory (INEE).

The presentation is extended also to the main researches performed in joint programs of the OCSE countries.