# INNOVATIVE CONCEPTS

*Summary :* To play a significant role in supplying the worlwide energy needs,nuclear energy has to fulfil some stringent requirements. No present solution appears to be able to fit these conditions and a large survey of the possiblities has to be made. These researches will take into account the works already made some time ago on unexploited possibilities and on the recent ones made very recently on partioning and transmutation. By using precise simulations, a large survey of the various possibilities may be done including combustible cycle,neutron spectra, breeding capabilities and scenarios allowing the transition to the various possible reactor systems. Some experimental studies are proposed on key issues of the most promissing systems: pyrochemical reprocessing platform, innovative materials for very high temperature and molten salt systems, neutronic studies for specific materials.Some tests on the physical properties of these innovative systems may be made on reactors like Masurca.

When dealing with energy production at the world level, the question has to be discussed as whole taking into account for each possible source the advantages and the drawbacks with at least the economical and environmental aspects. The nuclear energy, to be considered, has to fulfill some stringent conditions:

- to be breeder, in order to use the whole potentialities of the Uranium and Thorium fuels and to give a true energetic independance to the users.
- To produce as less long life nuclear wastes as possible to minimise the problems of transmutation and of long term disposal.
- To be safe with very good passive safety coefficients.

The last two conditions if we think about a notable part of the nuclear energy in the worlwide production that is to say a number of plants multiplied by more than an order of magnitude, implies larger gains on the waste production and on the safety. It would be also very interesting to diversify the ways of using of the nuclear energy and to be able to use the heat produced even at low temperature. Various reactor systems have been studied since the first studies on the nuclear energy but a large amount of the accumulated knowledge will be lost if we do not continue to work on these systems. As there are large change in the technologies,it may also be very interesting and fruitful to study again some specific systems. Starting with the hypothesis that the reactors systems have to be breeder involves that the possibilities are restricted to U-Pu fast neutron reactor or Th-U reactor with thermal or fast neutrons. As the thermal neutrons reactors requires much less fuel in the core, they are to be carefully taken in consideration. Likewise, any global project has to take into account the initial conditions which will allow or not to feed with fissile material and to take into account the doubling time. For exemple an interesting solution would be a two-stage situation where the Pu coming from the present reactors is used in FNR to generate U3 and the U3 is then used in molten salt reactors which would not be necessary breeder. This kind of scenario takes into account the present situation, works towards the decrease of the existing wastes and would require a lot of studies and of experimentations which are now described.

**Simulation studies of various possible reactors systems, of the fuel cycle, of the breeding abilities and of the strategies of transition.**

Owing to the large computer capabilities and of the precision that may be reached, it is possible to study with a good reliability various kinds of reactors and to obtain significative informations on the physical characteristics and on the safety coefficients. A first approach

will allow to obtain the main results for the following systems: Fast Neutron ReactorU-Pu or Th-Pu-U3 cooled with gas or liquid metal, Molten Salt Reactor with epithermal neutrons. These kind of study will give at a first glance the main characteristics of the various possibilities and to choose the ones which deserve more works. It allows to make more detailed calculations and experiences for the most promissing systems where the breeding and safety coefficient may be calculated. The transition scenarios will be studied in the same ways to be able to choose the ways which are the most efficient to use the present burned fuels and to produce the largest amount of fissile fuels with good safety coefficients

**Reactor physics**

Even with the most sophisticated stochastic codes which are supposed to be able to take into account the detail of the running of the reactor, some experimental verifications have to made. It is also very interesting from the point of view of the physics of the reactors to test some new ways to characterize the physical properties of the reactor. For exemple the used of a pulsed neutron source may open some new methods to characterize the reactivity. So we plan to do some specific experiments with Masurca and with some new prototype like XADS.

**Experimental key-studies for some selected systems**

Materials

For the innovative systems, the ability of the materials to withstand the corrosion, the high pressure and temperature and large irradiation will be key-point. So new specific materials are to be designed, produced and checked in order to be used as fuel support, cooling fluid or confining vessel .

Neutron Cross-sections

Most of the innovative systems will deal with low atomic mass materials or marerials related to the thorium cycle, both are not so well known than the materials used in the water reactors. So two kinds of experiments are foreseen to improve the validity of the nuclear data basis. In Grenoble a neutron slowing-down spectrometer is under construction which will allow to measure cross-sections of interest for the light materials: Li, Be,C, N, O ,F,...Using transfert reactions, a Bordeaux team prepares several measurements concerning the Thorium cycle and some Curium isotopes. By using direct neutron beam in the 0.5-3MeV range, they propose to renormalize the absolute neutron-induced fision cross-sections to drastically reduce the error bars( now at a level of 3%);

Platform to study the molten salt chemical properties

One of the main characteristics of the molten salt reactor is the interplay between the neutronic properties of the reactor and the chemical reprocessing. If we are able to pickoff, by the chemical reprocessing, products which capture a lot of neutrons or at the contrary to leave in the reactor products that we want to transmute, we will modify the properties of the reactor. So to better know the capabilities of the pyrochemical reprocessing in the molten salts, we have the project to build a molten salt loop where the extraction possibilities for various nuclei (U, Pa and fission products) will be studied using chemical and activition methods.