A NEW APPROACH FOR THE SYSTEMS DEDICATED TO THE TRANSMUTATION : THE REACTOR WITH COMPENSATED BETA

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Abstract

The hybrid systems are often presented as a solution with a future to incinerate nuclear waste. Indeed, the presence of minor actinides in fuel degrades certain neutron parameters, significant for safety, like the effective beta and makes difficult the realization of critical core dedicated to the transmutation. The operation of a core in sub critical mode, eliminates these problems. However, the design of an hybrid system of industrial size is rather complicated due to the power of the accelerator. This paper proposes, a new approach which tends to solve the problem upstream, i.e. to compensate for the intrinsic weakness of beta. The principle rests on the use of an adequate coupling between the accelerator and the neutron flux so as to simulate additional delayed neutrons. Thus, the level of sub criticality of the core can be very small and a commercial accelerator could be used. The whole of the system has the behaviour of a critical reactor having sufficient beta.

Summary

In France, 80% of electricity is of origin nuclear and the continuation of this means of production will rest, amongst other things, on the capacity to control waste. Our nuclear capacity is relatively young and a priori, to concentrate the incineration of waste with long life in some dedicated reactors appears more logical than to modify the whole of the park and the fuel cycle. This process is described as strategy of the double strata.

Waste to be incinerated includes minor actinides and some fission products. However, a high concentration of these elements in a core of reactor has consequence detrimental on the physical parameters which control the behaviour of the reactor and determine its safety. A solution to circumvent these bad effects consists in making operate these reactor on a sub critical level, with an external contribution of neutrons. The Accelerator Driven System (or ADS) implement this solution in which the auxiliary neutrons are produced by a source of spallation placed at the center of the core and supplied with a beam of protons produced by an external accelerator.

The association of an accelerator to a reactor produces an acceptable over cost in the frame of the double strata strategy (the ADS would account for approximately 5% of the park). On the other hand, the feasibility of the accelerators necessary to consider industrial incinerators is, today, very far from being acquired. The hard points relate to obtaining a beam of protons of several tens of MW and a level of reliability limiting the spurious shutdowns to some events a year.

These observations led to the proposal for a different approach, called "reactor with compensated beta (RCB)". Contrary to the ADS for which the low value of beta is circumvented by a margin of significant sub criticality, the proposal rests on a principle which aims at compensating for the weakness of beta. Practically, the RCB looks like an ADS because it includes a core, a target producing external neutrons and an accelerator. The difference is that the sub criticality of the core is very small (K = 0.997) and that the accelerator is controlled by the evolution of the neutron flux present in the core, according to a law simulating the concentration of delayed neutrons. Thus, the core being slightly sub critical makes it possible to reduce enormously the power of the accelerator. The dynamic control of the neutron source according to an adequate law confers on the external neutrons the property of delayed neutrons. So, even if the core itself is sub critical and as a low effective beta, the whole of the system has the behaviour and the characteristics of a traditional critical reactor. Apparent beta of this system include intrinsic beta due to the fuel, increased of the value of the level of sub criticality of the core. Obviously, the RCB must be associated with the concepts of cores not being able to melt, to avoid all risks of criticality in the event of accidents.