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Title : " SUPER PHENIX - CORE CONFIGURATION DEVOTED TO Pu BURNING "

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Introduction

SUPER PHENIX, the 1200 MWe french fast reactor has been restarted on the fourth of August 94, after four years of non operation. During this period, the decrease of potential core reactivity has been about 1000 pcm. The reason of the loss of reactivity is the decrease of Pu 241 in Am 241.
This reactor is now devoted to demonstrate the ability of a fast reactor to burn Plutonium and minor actinides.
In this way at 320 EFPD (Equivalent Full Power Days), the core design will be modified in considerable proportions :

- The first row of fertile blanket will be replaced by a steel reflector to make the breeding gain decrease (about 5 kg/Twhe).

- The introduction of 2 subassemblies with high Plutonium enrichment, about 30%. The isotopic composition of these sub assemblies are different, one represented the UOX PWR (CAPRA 1A) the second one representated MOX PWR (CAPRA 1B). The first one is placed in the outer core, the second one in the inner core. They are devoted to demontraste the ability of SUPER PHENIX to burn Plutonium (in the frame of CAPRA project).

- The introduction of one subassembly with 2 kg of Neptunium 237 in homogeneous mixture. This type of subassembly is devoted to demonstrate the ability to burn Minor Actinides in SUPER PHENIX.

- The introduction of 24 subassemblies to boost the core. In SUPER PHENIX there are two fissile zones of Pu enrichment, the inner core with an average 15 % Pu and the outer core with an average 19% Pu.The 24 sub assemblies are of the outer core type, and they are set in inner core to increase the reactivity. The effect on the reactivity is about 2000 pcm.

A core configuration was reached that will authorize the reactor to run with high level of power. We have considered in our investigation four safety criteria. The respect of these limits the reactor power level.

At nominal power (1200 MWe) their values are :

1 - Maximum Linear Power under 480 W/cm.

2 - Maximum Clad Temperature under 700°C.

3 - No melted fuel when a control rod is untimely ejected out of the core.

4- The antireactivity of the Backup Shutdown System (B.S.S.) must stop the reactor and must be efficient up to 550 °C.

Criteria 1 and 2 must be respected in operation,Criteria 3 and 4 should be respected in accident configuration.

Effects of core design modifications

The replacement of the first row of fertile blanket induces two effects :

- an increase of flux level in the outer core by reflecting effect,
- an increase of power in the second fertile row because steel reflectors are more transparent to neutrons than standard fertile subassemblies.

The introduction of the 2% Np237 subassemblies has no effect on power.

The introduction of CAPRA subassemblies increases the linear power of S/A near them (See fig1)

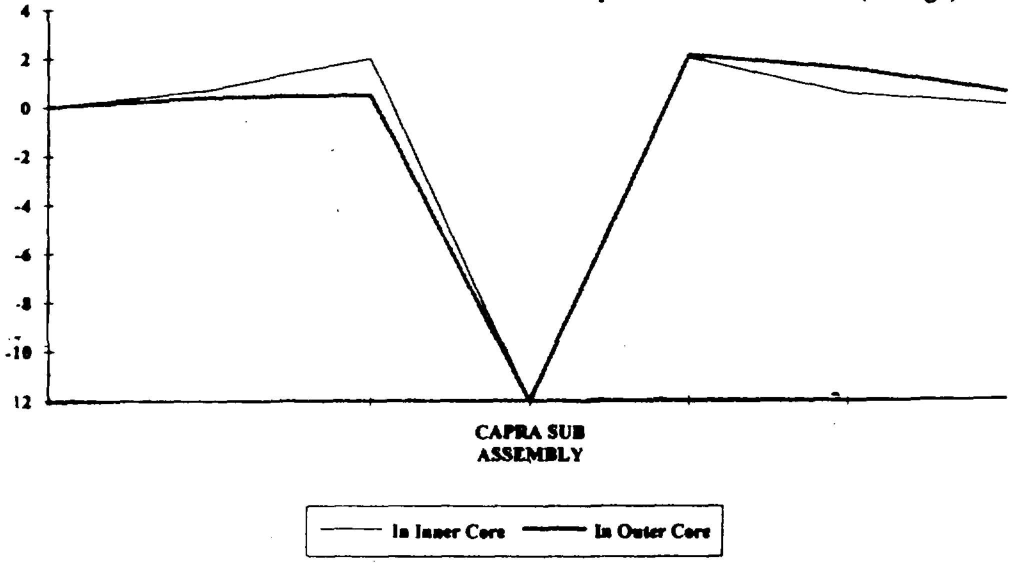

fig 1 - Gap in percents on Max. Linear Power between configurations with and without CAPRA S/A (radial cross)

The local increase of linear power is no more than 2%, and the effect disappears from the second row around. The CAPRA S/A are colder than a standard fuel S/A because of a lower content in Pu 239 equivalent.

The permutations of inner core subassemblies by booster S/A increase linear power and cladding temperature in such positions (see fig 2)

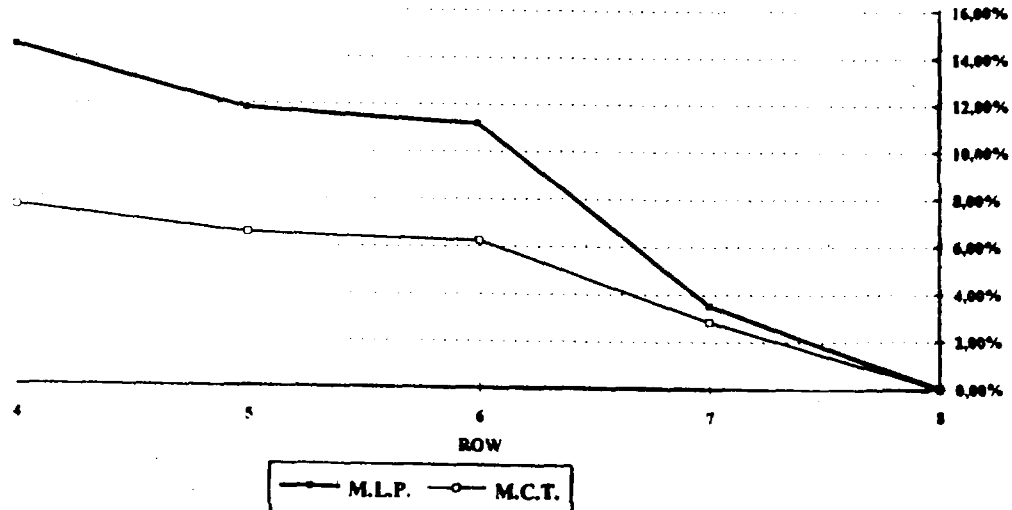

fig 2 -Relative variation of MLP and MCT for Booster Assemblies in function of their positions

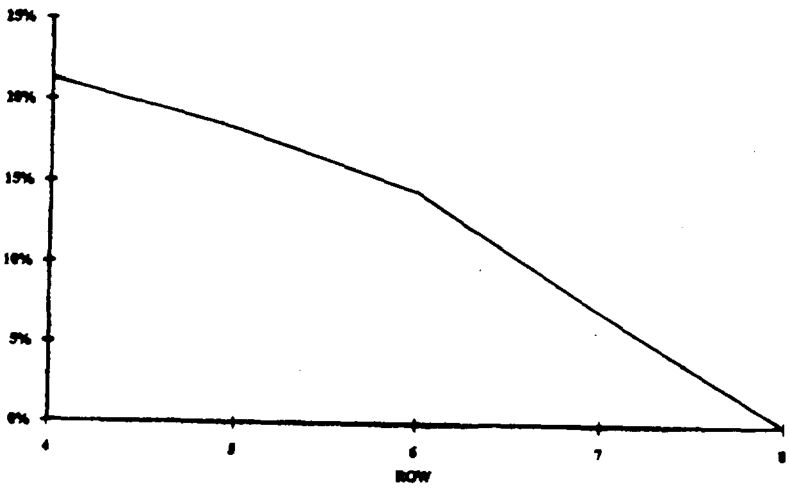

fig 3 - Relative variation of reactivity with the position of booster subassemblies in the inner core

In fig 2 we can see that the relative variation increases when booster S/A are brought near the center of the core. In the same time the reactivity effect is more important (see fig 3).

The injection of reactivity is made in three times, at 320, 480 and 560 EFPD. A new core design corresponds to each situation, with more booster subassemblies in the inner core :

- 6 Booster S/A at 320 EFPD
- 15 Booster S/A at 480 EFPD
- 24 Booster S/A at 560 FPD

The penalization (%) on the power level to respect the criteria 1 and 2 is

320 EFPD	480 EFPD	560 EFPD
10 %	15%	20%

At 320 EFPD two option are considerate to decrease the BSS criteria :

	booster S/A near BSS rods	booster S/A far BSS rods
Penalization in % (B. S. S. criteria)	5%	30%

The implantation of the S/A near the BSS drop is very interesting to decrease the penalization about this criteria. This configuration has no effect on the others criterias.

Conclusion

All of these modifications call for detailed studies to take into account the effects they introduce. The first studies indicate that the new orientation of ***SUPER PHENIX*** as a reactor devoted to Pu burning and the first transformation with the replacement of the first row of fertile S/A and the introduction of CAPRA S/A have no effect on the power level of the reactor during operation. The ***CIRANO*** experimental programme, started in 1994, in the critical facility ***MASURCA***, in support of the CAPRA project, allows to validate the calculations.
The introduction of booster S/A required to bring an important amount of reactivity (about 2000 pcm) to reach high burn up fraction, The penalization on the power level to respect safety criterias is about 15%. There are no coupling effects between Booster S/A and CAPRA S/A if they are far enough from each other.