

**Comments on thermal feedbacks in ADS and
the possible role of the SAD experiment.**

1. The dynamic behaviour of source driven sub-critical systems (ADS) is an important topic to be investigated, especially with respect to the differences compared to critical reactor systems. In the original proposal for the 6. EC FP IP EUROTRAND DM2 TRADE-PLUS extensive investigations were planned to study the effects of the thermal feedbacks from the fuel in the TRIGA reactor SC-1 in Cassaccia, Italy. The negative temperature feedbacks in TRIGA fuel are very large because of the specific Zirconium hydride fuel characteristics and because of the well thermalized neutron spectrum in the core.
2. The SAD experiment in Dubna was originally designed to investigate, at low power, the physics behaviour of an ADS with real coupling of the three main components: high energy proton beam, heavy metal spallation target and fast spectrum sub-critical core. For the study of the dynamics behaviour of ADS, experiments with reactivity perturbations and with proton beam perturbations are envisaged. Initially, thermal feedbacks were not considered because of the MOX fuel and the fast neutron spectrum, both prototypical for future ADS, only have small temperature reactivity coefficients. Moreover, the low power of about 20-25 kW leads to only moderate temperature increases in the fuel (approx. 50 C) in the current design.
3. In view of the strong efforts in the TRADE-PLUS proposal to study temperature feedbacks in this ADS experiment, preliminary considerations have been started to make an assessment of the capabilities of the SAD set-up to study temperature feedback effects. A natural way to increase the temperature feedback reactivity is to increase the fuel temperature rise in the core. Here, several options may be considered, e.g.:
 - a. Increase of the core power
 - b. Decrease of the coolant flow
 - c. Injection of heated air
4. Aspects of the increase of the core power have been analysed in some detail in connection with the 2. SAD/YALINA Steering Committee Meeting in January 2005 in Minsk, Belarus. More information may be found in the minutes of this meeting.
5. Consequences of the possible decrease of the coolant flow will be discussed in the subsequent sections. Injection of heated air also could be an interesting option and should be kept in mind.
6. The current nominal coolant temperature increase passing the core amounts 48 C (why top->down flow?). The core flow amounts 0.6 kg/s through a pipe of 20 cm diameter. This corresponds to approx. 50 m/s air velocity. The mean time to pass the 60 cm core height is about 12 ms.
7. Reduction of the mean coolant velocity leads to an increase of the mean core temperature. As the fuel rods are of BN600 design, much higher temperature rise than 48 C could be envisaged to obtain larger temperature feedbacks. Limiting parameters probably are the maximum cladding temperatures.
8. Assuming as a first guess 200 C temperature increase would require a coolant velocity of about 10 m/s with core residence time of about 50-60 ms.

9. From neutron-physics and thermo-dynamics point of view, it is of high interest to know the detailed temperature distributions in the core and especially the influence of cross flow effects. These temperature distributions can be estimated by appropriate tools, e.g. CFD codes. Validation of these tools by proto-typical experiments for a large range of coolant velocities seems to be of interest, especially for the case that variation of the coolant velocities to study feedback effects in SAD will be included in the experimental program.
10. An experimental ADS set-up, like SAD, with space-dependant feedback effects between neutron physics (sub-criticality level!) and thermo-hydraulic (e.g. cross flows) behaviour is of high interest for the validation of coupled multi-physics simulation systems.
11. An important question is at what coolant velocity the cross flows will become significant (1..5..10 m/s??) in the SAD set-up.
12. As a first conclusion, consideration of well prepared proto-typical thermal-hydraulic experiments for the SAD set-up seems to be of interest, especially in the case that coolant flow variations will be included in the SAD experimental program, to study (space dependant) temperature feedback effects during transients like beam shut-on/off.
13. In view of loss of coolant failures, it could also be considered to perform experiments with low flow rates in a mock-up of the SAD core set-up.