Severe Accident Research Network of Excellence
Newsletter N°2 (April 2010)

The first period of the SARNET2 project (follow-up of the SARNET FP6 project) in the 7th European Framework Programme has now finished after one year. A new partner has recently joined the network: KINS from Korea. The preparation of the 4th SARNET Conference, foreseen in May 2010, is under way. Many joint R&D tasks, gathering several partners, have been launched in this period like benchmarks between codes or state of the art reports. Several experiments are also today in preparation in order to bring new data and understanding on the most important severe accident phenomena.

Amendment of the Grant Agreement

An amendment of the Grant Agreement has been signed by DG-RTD (European Commission) and IRSN (coordinator's organisation) in early April. This amendment was necessary for two reasons:

- Change of legal names of partners KIT-G (named KIT in the newsletter) in Germany (instead of FZK), Tractebel Engineering in Belgium (instead of Suez-Tractebel), NUBIKI in Hungary (instead of VEIKI),
- Entry of a 42nd partner: KINS (Korean Institute for Nuclear Safety) Technical Safety Organisation in Korea.

A change occurred in the Management Team: Prof. Sandro Paci (University of Pisa, Italy) is replacing Prof. Bal Raj Sehgal (University of Stockholm, Sweden) for coordination of the WP2 "Spreading of Excellence". Prof. Sehgal's work will focus on the scientific review of the SARNET Book on severe accidents.

MT members (Karlsruhe 3rd meeting)

The 1st meeting of the Steering Committee, in Paris on March 23, gathered the representatives of the 10 members (AREVA NP GmbH, CEA, CIEMAT, EDF, GRS, INRNE, IRSN, KIT, KTH, PSI) to examine the outcomes of the 1st network period and the perspectives. The 2nd period of the network has started on April 1, 2010, for a duration of 18 months (thus until Sept.2011). The Joint programme of Activities (JPA2) for this new period is under elaboration and should be released in May.

SC members (Paris meeting)

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Public web site of the network

In March 2010, the public web site has been opened: http://www.sar-net.eu. The website is intended to present up-to-date information on the activities within the SARNET Network of Excellence to the public interested in the subject of severe accidents.

Homepage of the public website

The website contains an overview on the organisation of the network, the scope of the project, and the expected results. The research activities, structured according to the work packages in the project, are described in more detail. The information on the project is enhanced by announcements of SARNET events, a list of the

participating organizations, and the contacts to project and work package leaders.

The information on the project activities is kept up to date by publishing the series of newsletters on the website. This information is completed by the reference document section containing documents describing the project itself, giving the links to publications in scientific journals, and including the presentations held in conferences.

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ERMSAR Conference

The 4th ERMSAR Conference (European Review Meeting on Severe Accident Research) of the SARNET network will be hosted by ENEA in Bologna (Italy) on May 11-12, 2010. It will extend on almost 2 days. The programme will include 5 invited papers about the overview of SA studies in BARC (India), the different new LWR types analysed in Finland, the ASAMPSA2 FP7 project on PSA2[2] harmonisation, the PANDA containment experiments, and the South-African applications of the ASTEC integral code to HTRs[3]. The network partners will present papers on their joint work, including some conclusions of the work done in the first period.

[2] Probabilistic Safety Assessment
[3] High Temperature Reactors

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The joint OECD-SARNET workshop on in-vessel corium coolability

A joint OECD/NEA – SARNET workshop on In-vessel Coolability was organised at the NEA (Nuclear Energy Agency) Headquarter (Issy-les-Moulineaux, France) in 12-14 October 2009. ON SARNET side, the preparation and the organisation were shared by KIT, IRSN, PSI and GRS representatives. Even though Severe Accident Management Guidelines (SAMGs) increase focus on containment integrity after some progression in the course of a severe accident, trying to cool the degrading fuel and/or the corium within the Reactor Pressure Vessel (RPV) is a way to slowdown or stop the progression of an accident.

The workshop was organised in 4 technical sessions: general studies, experimental work, phenomenological and modelling work, and specific reactor studies. Twenty-two papers were presented, authors being members of research organisations, industry and technical safety organisations. Sixty-six people attended the workshop, coming from Belgium, Bulgaria, Canada, Czech Republic, Finland, France, Germany, Hungary, Italy, Korea, Slovak Republic, Spain, Sweden, Switzerland, United Kingdom, United States and OECD/NEA Secretariat.

As a result of discussions, there was a general agreement on the importance of the In-vessel coolability issue. The likelihood to stop the progression of a core melt-down accident by water injection is generally considered as high in the early phase of core degradation and depends on reactor specific features, nevertheless, even in later stages e.g. during the corium relocation in the lower head, cooling still can be achieved but depends on reactor specific features and the accident scenario.

Ongoing, starting and planned experimental programmes address the coolability issues in the different relevant configurations, i.e. reflooding of bundles, debris beds, molten pools and RPV external cooling. The code developments are promisingly directed towards a more mechanistic approach using a porous medium modelling to treat the different configurations of a degraded core. Nevertheless, the models to describe adequately the relocation of parts of the molten core to the lower head and the debris bed formation still need further development and validation against the results of ongoing experimental programmes. The transposition of results to the reactor scale where multi-dimensional effects are expected needs to be evaluated, all the more as larger scale experiments are probably not feasible.

Another way to cope with the uncertainties is to implement specific engineered features and/or management procedures to act on influential parameters such as an increase of the available water mass flow rate. Specific examples were given: good prospects for external RPV cooling for VVER-440/213 reactors; use of spray found efficient for Sizewell B PWR; potential of Control Rods Guide Tubes flow to cool molten pools in BWRs.

The following recommendations were given at the final panel discussion: although it was concluded that the present efforts to solve the issue are well-oriented, feedback experience from the analysis of safety cases of Nuclear Power Plants having, planning and/or contemplating the implementation of specific engineered features to solve this issue would be of great benefit. It is expected that ongoing experimental programmes and analytical efforts will help making progress in the coming years. Finally, the suggestion of organising a follow-up workshop on in-vessel coolability was given.

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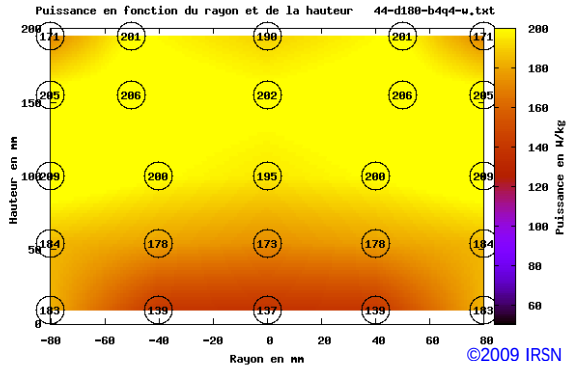
PRELUDE experiments on debris reflooding

The objective of the PEARL program in IRSN (Cadarache, France), within the Work-Package 5 ("Corium and debris coolability") is the validation of numerical tools to predict the consequences of the reflooding of a severely damaged reactor core where a large part of the core has collapsed and formed a debris bed, i.e. prediction of debris coolability and steam production during quenching. A step-wise experimental approach has been adopted with a preliminary program (PRELUDE) to test the performance of the induction heating system on stainless steel particles simulating debris beds and to optimize the instrumentation in a two phase flow, for a better design of the PEARL facility. The PRELUDE facility includes: a water tank for reflooding with flow measurement, a test section containing a debris bed with thermocouples, an induction furnace (coils around test device, high frequency generator), and a downstream heated vertical tube to remove steam from test section, including a steam mass flow rate device.

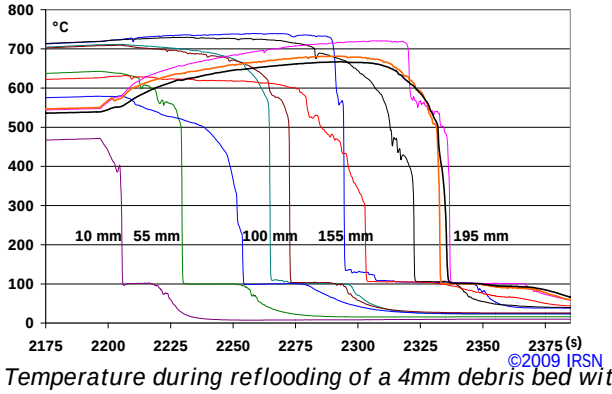
PRELUDE facility ©2009 IRSN

Preliminary reflooding tests involved a debris bed of 4 mm particles inside a 110mm x 100mm section, investigating the effect of inlet water velocity, power (maintained or not during the reflooding phase), and initial temperatures (up to 330°C). Additional tests were performed to evaluate the power distribution inside a larger debris bed diameter (up to 280 mm) using stainless amagnetic steel particles (the Figure below illustrates the rather well uniform specific power). This campaign ended with a heating sequence of a debris bed up to 820°C before water injection. One can remark on the Figure below the difference between thermocouples inside and outside the beads: for a same location, cooling time of particle lasts few seconds more than in the void. It can be also noticed that the cooling of the thermocouples in the bottom part of the bed is much shorter than the cooling of the thermocouples in the upper part. Thermocouples inside the debris bed offer a fine illustration of different phases of reflooding.



Radius (mm)

Power distribution in PRELUDE (W/kg)



Temperature during reflooding of a 4mm debris bed with 200W/kg power deposit inside

The results obtained so far show that the chosen technology is able to deposit a sufficient power density during the reflooding phase. Moreover the level of 920°C is reached with induction system.

The injected water flow and the steam flow rate generated during reflooding were accurately measured with adapted sensors to reach a rather good water/steam balance. Tests will continue in 2010 to qualify the pressure measurement inside the debris bed. Reflooding experiments will be performed on a homogenous debris bed up to 1000°C with 1 to 2 mm diameter particles. In parallel, PEARL facility design has been completed; construction will start in the second half of 2010, qualification being planned at the beginning of 2011 to run experiments at pressure up to 10 bar.

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LACOMECO project

The 1st call for proposals for the LACOMECO (Large-scale experiments on core degradation, melt retention and containment behaviour) FP7 project has been launched. The objective is to provide research institutions from EU Member States (except Germany) and Associated States with access to 4 experimental facilities: QUENCH (quench behaviour of fuel rod simulators), LIVE (melt behaviour in vessel lower head), DISCO-H (direct containment heating) and HYKA (hydrogen behaviour and mitigation). Access is provided free of charge to interested users or user groups, including all infrastructural, logistical, technical and scientific support needed to perform selected experiments. Travel and visit subsistence costs may also be covered. Please visit: http://www.fzk.de/lacomeco or contact alexei.miassoedov@kit.edu

Ongoing work on Containment issues

Ex-vessel fuel-coolant interaction

- Role of void in steam explosions as calculated with MC3D and IDEMO computer codes,
- Void build-up in fuel-coolant premixing phase,
- Solidification / material effect: comparison of model currently developed for MC3D code, and characterization of the influence of the material effect on melt solidification,
- Preliminary calculations for a fuel-coolant interaction test in the DISCO (KIT, Germany) experimental facility.

Benchmarks on containment issues

Several benchmarks between codes have started:

- On containment sprays, consisting in simulation of elementary heat and mass transfer experiments (IRSN, France, organizing; 10 participants): separate uniform droplets were injected into a vessel with a controlled atmosphere.
- On hydrogen combustion (IRSN organizing; 8 participants): simulation of experiments in the ENACCEF facility (CNRS, Orléans, France).
- On steam condensation (University of Pisa, Italy, organizing; 14 participants): simulation of experiments in the CONAN facility (University of Pisa).
- On development of a generic containment model (FZ Jülich, Germany, organizing; 12 participants). The purpose is to compare code results by simulating a transient in a precise and unique containment model, based on the containment of a German nuclear power plant.
- On Passive Autocatalytic Recombiner (PAR) interaction with containment atmosphere (GRS, Germany, organizing; 10 participants): simulation of two experiments using PARs in the THAI facility (Becker Technologies, Germany).

Hydrogen combustion under Direct Containment Heating conditions

Experiments in a large-scale experimental facility (200 m^3 volume) are being prepared, which includes simulations and analysis of results.

Experimental facility at KIT for DCH experiments

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Forthcoming events

May 10, 2010: 1st General Assembly in Bologna (Italy)

May 11-12, 2010: 4th ERMSAR Conference (European Review Meeting on Severe Accident Research), hosted by ENEA in Bologna

June 13-17, 2010: 1st general paper on SARNET2, ICAPP'10 conference, San Diego (USA)

Oct.5, 2010: 4th Management Team meeting in Aix-en-Provence (France)

Oct.9, 2010: WP8 "Source Term" technical workshop, hosted by IRSN in Aix-en-Provence

Oct.11-15, 2010: 4th ASTEC Users Club, hosted by GRS in Köln (Germany)

Nov.2010: WP6 "MCCI" Meeting, hosted by IRSN in Cadarache (France), after OECD MCCI Seminar

January 11-14, 2011: Course on SA phenomenology, including Gen.III NPPs, hosted by University of Pisa (Italy)