Molten core/Concrete Interaction

Arkusz informacyjny

Informacje na temat projektu

MCCI

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Extended studies on the safety of LWRs have emphasized the important role of ex-vessel melt behaviour during postulated severe core meltdown accidents. There is a potential for erosion of the sacrificial layer and/or of the concrete basemat with the possibility of basemat penetration and of loss-of-containment integrity as well as for the generation of non-combustible gases. Depending on the accident sequence and the cavity design the problems of "Direct Containment Heating" (for high pressure failure of the reactor pressure vessel) or "Ex-vessel Melt-Water Interaction" (for water present in the reactor pit) could dominate the interaction process. During the interaction of the molten core material with the concrete floor aerosols may be generated by evaporation from the hot melt surface and by the mechanical agitation of sparging gases, which contributes to the increase of the radioactive source term.

The project includes the experimental investigation and the numerical simulation of...
the key phenomena associated with the corium coolability. Some efforts are
dedicated in particular to R+D requirements for core melt retention devices (e.g. core
catchers).

Spreading of Corium Melts on Large Surfaces

CORINE 1 program was completed as planned concentrating on the hydrodynamic
spreading of fluids under the influence of gravity, inertia, and viscosity. The
experiments so far did not include freezing processes or gas release from the
horizontal surface. The spreading geometry is a 6 meter long angular sector of 19.
The experiments are documented and compared with analytical solutions, which will
be extended to include the viscosity effect.

Ex-Vessel Corium Cooling

The theoretical activity of ENEL in this field is associated with a cavity concept based
on corium spreading on a refractory horizontal surface cooled downside by boiling
water, and avoiding direct contact of melt and water. A study on the possible
recriticality pointed out that the neutronic aspect is important with respect to the
selection of geometry and structural material. A literature review on candidates for
structure materials with high melting points showed that, as the literature is quite
poor in this area, representative tests with prototypic components are needed. The
computer model CORIUM-2D was developed to calculate the time dependent heat
transfer and temperature fields in the flat cavity arrangement covered with corium.
For heat transfer to the water layer, conventional boiling heat transfer relations are
used. The code was tested for sample problems and has to be applied in the next
step to the structure under consideration to identify the main characteristics of such a
concept.

Thermal Radiation Exchange between the Corium Surface and its Environment

Studies were performed to prepare the experiments: The heating technique was
developed and tested with CeO2 and ZrO2 melts, simulating the electrical behavior
of corium. The improved induction heating uses a susceptor technique in a self
crucible to avoid unfavorable material interactions. Further tests are underway to
improve the applicability in the real AEROSTAT tests.

Theoretical studies were carried out to describe the aerosol cloud above the melt
surface, the aerosol release from the melt by use of the thermochemical CHEMSAGE
code (calculation done by Siemens), and the heat transfer in the AEROSTAT vessel
to predict and understand the future experiments.

In the WECHSL code, models for oxidic melt properties, especially for the dynamic
viscosity of oxide mixtures, were reviewed and corrected to achieve better
agreement with available viscosity measurements. Recent viscosity measurements
of the ACE oxidic melts show substantially higher values than earlier reported and a strong dependence of viscosity on temperature. To account for the influence of the cold and highly viscous sublayer in the thermal boundary layer of the convecting melt, heat transfer models in WECHSL were modified by use of the property ratio method. Comparison with the ACE experiments shows a substantial improvement of the calculations.

Work programme

A State-of-the-Art Report has been produced summarizing the current knowledge of MCCI and of Corium Coolability, based both on experimental and theoretical investigations.

A series of experiments regarding the coolability of corium melts are conducted at KfK in the frame of core catcher evaluation with emphasis on the optimization of sacrificial materials: the spreading of corium melts on large surfaces is investigated in the modified BETA facility by flooding the melt through openings from the bottom (COMET tests). A staggered-pan core catcher with ceramic spheres is developed in another KfK facility. IKE/Stuttgart provides a theoretical support to the COMET experiments, using their computer code IKEJET to optimize the coolant water supply pressure and IDEMO to predict the pressure build-up and the resulting mechanical loads in the case of corium fragmentation. Other research efforts towards a core catcher concept for future reactors are carried out at CEA-DRN/Cadarache in the VULCANO-E30 facility with real materials and at CEA-DRN/Grenoble in the CORINE facility with simulants. One of the scopes is to validate new heat transfer and axially varying viscosity models in 2-D corium spreading computer codes like CORFLOW from SIEMENS-KWU/Erlangen. Problems of radiation heat transfer, which contributes substantially to the coolability of flat melts, and corium/concrete aerosols formation are examined through a series of AEROSTAT experiments at CEA/Cadarache. The WECHSL computer code describing the melt/concrete interaction under dry conditions is being improved, especially with respect to the oxidic melt behaviour and the thermal boundary layer. The ESCADRE programme also benefits from the above experiments. The thermodynamics of multiphase multi-component equilibria of fission products and fuel/concrete aerosols is computed by ECN/Petten and AEA/Winfrith for a series of different thermal-hydraulics conditions. In particular chemical activities and thermal measurements for corium-concrete mixtures are provided in the cases of limestone as well as limestone-common sand concretes under various severe accident conditions. The ENEL-VDN/Milano contribution consists of applying the EDF-ENEL computer code CORIUM-2D to a series of heat transfer problems including radiation and boiling effects.

Program(-y)
Temat(-y)

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