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Results of the QUENCH-L2, DISCO-L2, and COMET-L2 experiments performed within the LACOMERA project at the Forschungszentrum Karlsruhe

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Abstract

The LACOMERA project at the Forschungszentrum Karlsruhe, Germany (FZK) is a 4-year action within the 5th Framework Programme of the EU which started in September 2002. Overall objective of the project is to offer research institutions from the EU Member Countries and Associated States access to four large-scale experimental facilities QUENCH, LIVE, DISCO, and COMET. These facilities are being used to investigate core melt scenarios from the beginning of core degradation to melt formation and relocation in the vessel, possible melt dispersion to the reactor cavity, and finally corium concrete interaction and corium coolability in the reactor cavity. The paper summarizes the main results obtained in the following three experiments:

QUENCH-L2: boil-off of a flooded bundle. The test is of a generic interest for all reactor types, provided a link between the severe accident and design basis areas, and would deliver oxidation and thermal hydraulic data at high temperatures.

DISCO-L2: fluid-dynamic, thermal, and chemical processes during melt ejection out of a breach in the lower head of a pressure vessel of the VVER-1000/320 type of reactor.

COMET-L2: investigation of long-term melt–concrete interaction of metallic corium in a cylindrical siliceous concrete cavity under dry conditions with decay heat simulation of intermediate power during the first test phase, and subsequently at reduced power during the second test phase.

1. Introduction

The principal objective of the LACOMERA project (Miassoedov et al., 2003) is to provide the interested partners of the European Member Countries and Associated States a focus on core quenching and on possible core melt sequences in the reactor pressure vessel (RPV) and in the reactor cavity, to enhance the understanding of severe accident sequences and their control in order to increase the public confidence in the use of nuclear energy. The various large-scale experiments being performed within the LACOMERA project aim at providing data for a better understanding of possible scenarios of core degradation and of different core melt sequences that can help to improve severe accident measures and to reduce the severity of the consequences.

In detail, the experiments within the LACOMERA project concentrate on the following topics:

- Main factors governing the hydrogen production and melt generation during core quenching (QUENCH).
- Time span of melt relocation to the lower plenum and measures needed to regain coolability (LIVE).
- Location of the melt after failure of the RPV under moderate pressure, with different failure positions. Pressure increase in the reactor pit, the subcompartments and the containment due to thermal and chemical reactions, such as hydrogen production and burning (DISCO).

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- Long-term erosion rates during molten corium concrete interaction (MCCI) and ex-vessel melt coolability (COMET).

Eight organisations from five countries participate in preparation, performance, and analysis of eight experiments which have been specified within the LACOMERA project. The results of the experiments QUENCH-L1, DISCO-L1, and COMET-L1 have already been reported by Miassoedov et al. (2005). In the following, test parameters and main experimental results of the newly performed experiments QUENCH-L2, DISCO-L2, and COMET-L2 are discussed in more detail.

2. Main results of the QUENCH-L2 test

Bundle experiments in the QUENCH facility (Sepold et al., 2001) are designed to contribute to the reduction in uncertainties and increase in understanding of the quenching process that will be necessary if a proper assessment of the risk posed by quenching to full-scale power plants is to be reached.

The main component of the QUENCH test facility (Sepold, 2004) is the test section with the test bundle (Fig. 1). Superheated steam from the steam generator and superheater together with argon as a carrier gas enter the test bundle at the bottom. Argon, steam, and hydrogen produced in the zirconium-steam reaction, flow from the bundle outlet at the top through a water-cooled off-gas pipe to the condenser where the steam is separated from the non-condensable gases argon and hydrogen.

The test bundle is made up of 21 fuel rod simulators, each with a length of approximately 2.5 m. Twenty fuel rod simulators are heated electrically over a length of 1024 mm, an unheated fuel rod simulator is located in the centre of the test bundle.

For temperature measurements the test bundle, shroud, and cooling jackets are equipped with thermocouples at different elevations and orientations. Gas analysis is performed online by a mass spectrometer located at the off-gas pipe and a hydrogen detection system located behind the condenser.

The experiment QUENCH-L2 on boil-off and subsequent quenching is dedicated to investigate degraded core reflood situations with a rather low mass flow rate, which may occur if pumps cease and/or if low make-up systems are activated in the course of accident management measures (AMM). The test conditions simulated a depressurized plant sequence in which the core would be essentially dried-out and with a limited steam flow due to boiling of residual water in contact with the hot structures in the lower plenum. The test was proposed by the Institute for Nuclear Research and Nuclear Energy, Sofia, Bulgaria (INRNE) and supported by Paul Sherrer Institute, Switzerland (PSI).

In contrast to all the previous QUENCH experiments, the bundle was initially filled with water and slowly evaporated. Among other facility changes, an auxiliary heater and an addi-

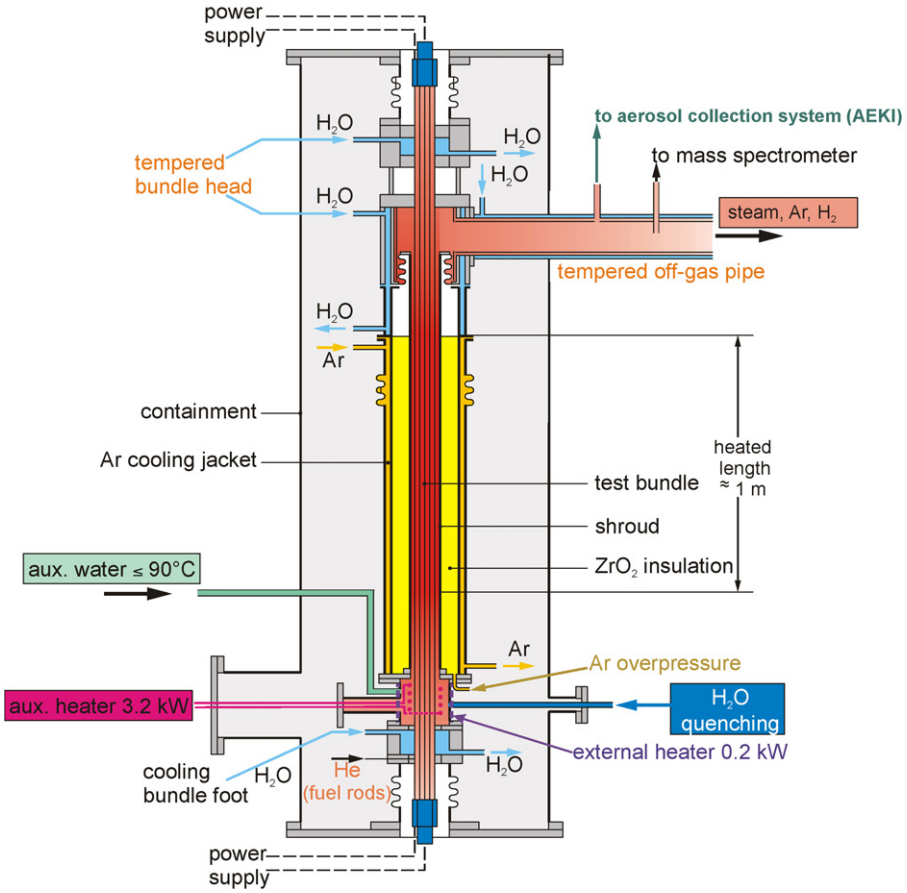

Fig. 1. QUENCH test section.