MOLTEN CORE RELOCATION ANALYSIS OF CORA-17 AND CORA-18 FOR THE SAMPSON/MCRA VALIDATION

A. Prestigiacomo, A. Costa, and H. Ninokata
Dipartimento di Energia
Politecnico di Milano
via La Masa 34, 20156 Milano - Italy
andrea.prestigiacomo@mail.polimi.it; alessandro@iae.or.jp; hisashi.ninokata@polimi.it

M. Pellegrini, M. Naitoh
The Institute of Applied Energy
Shimbashi SY Bldg. 1-14-2 Nishi-Shimbashi, Minato-ku, Tokyo - Japan
mpellegrini@iae.or.jp; mnaito@iae.or.jp

ABSTRACT

Severe core damage accident analysis of Boiling Water Reactor (BWR) has gained more importance after the Fukushima-Daiichi nuclear accident in March 2011. The accident progression phenomena are governed by those mechanisms including chemical, metallurgical as well as thermal hydraulics interactions among the core materials. An exothermal reaction, i.e., high temperature Zirconium-steam interaction could lead to a temperature excursion affecting the melting progress by a positive feedback. Moreover the geometry of a BWR core complicates the modeling. The existence of channel boxes and control blades represents a significant challenge for heat transfer calculations, in particular with the thermal radiation that could not be neglected. In this paper the CORA-17 and CORA-18 experiments carried out at KfK have been selected as validation basis for the information on the damage progression of a BWR fuel element. Simulations of those experiments have been performed with the severe accident analysis code SYSTEM SAMPSON/MCRA where the models required for simulating those tests have been implemented. In the experiments the Zirconium oxidation assumes to be more important as the temperature gets higher than 1300 K, leading to a considerable heat release and hydrogen generation. Moreover a quenching phase followed the heaters shut down in the CORA-17 experiment, resulting in a much more hydrogen generation. Calculated temperature transient, rate of hydrogen generated and effects of oxidation for both CORA-17 and CORA-18 will be compared with the corresponding experimental results.

KEYWORDS
Severe accident, Molten Core Relocation, BWR, SAMPSON, validation.

1. INTRODUCTION

During the progress of severe nuclear accident, one of the most dangerous circumstances that could occur is the core melting event. Many phenomena can affect the accident progression. Among them, the most critical is represented by exothermal chemical reactions such as Zircaloy oxidation through steam interaction, resulting in hydrogen generation. This accidental condition in Boiling Water Reactors (BWRs) is more dangerous compared to Pressurized Water Reactors (PWRs) because of a larger Zr inventory within the core (e.g. the presence of channel boxes). In addition, the presence of boron carbide

6. A. Costa, M. Pellegrini, H. Mizouchi, H. Suzuki, M. Naitoh, H. Ninokata, M. E. Ricotti, *"Validation of the SAMPSON/MCRA code against CORA-18 experiment"*. Proceedings of ICONE 23, Chiba, Japan, 2015.
7. G. Schanz, B. Adroguer, A. Volchek, *"Advanced treatment of zircaloy cladding high-temperature oxidation in severe accident code calculations: Part I. Experimental database and basic modeling"*. Nuclear Engineering and Design, vol. 232, pp. 75-84, 2004.
8. P. Hofmann, M. Markiewicz, J. Spino, *"Reaction Behavior of B_4C Absorber material with Stainless Steel and Zircaloy in Severe LWR Accidents"*. KfK 4598, Kernforschungszentrum Karlsruhe GmbH, Karlsruhe, Germany, 1989.
9. P. Hofmann, M. Markiewicz, *"Chemical Interactions between as-received and pre-oxidized Zircaloy-4 and Stainless Steel at High Temperatures"*. KfK 5106, Kernforschungszentrum Karlsruhe GmbH, Karlsruhe, Germany, 1994.
10. T. Haste, M. Steinbrück, M. Barrachin, O. de Luze, M. Grosse, J. Stuckert, *"A comparison of core degradation phenomena in the CORA, QUENCH, Phébus SFD and Phébus FP experiments"*. Nuclear Engineering and Design, vol. 283, pp. 8-20, 2014.