Thermal Hydraulic Study of Natural convection in the Heavy Eutectic liquid metal Loop HELIOS, Benchmark RESULTS on Lead-Alloy Cooled Advanced Nuclear Energy System (LACANES)

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Abstract

Liquid lead-bismuth eutectic (LBE) has been extensively investigated in worldwide because of their low melting temperature, high boiling temperature, chemical stability and neutron transparency. The study of natural convection heat transfer of liquid metals becomes very important for the safety of next generation nuclear reactors. Design tools validation like system codes and computational fluid dynamic (CFD) models requires reliable experimental data. Under the guidance of the Nuclear Science Committee (NSC) and the mandate of the Working Party on Scientific Issues of the Fuel Cycle (WPFC), the Task Force on the Benchmarking of Thermal-Hydraulic Loop Models for Lead-Alloy Cooled Advanced Nuclear Energy Systems (LACANES) is started. One of the objectives of this WPFC is the validation of thermal-hydraulic loop models for application to LACANES design analysis in participating organisations, by benchmarking with a set of well-characterised lead-alloy coolant loop test data. Other objectives are establishment of the guidelines for quantifying thermal-hydraulic modelling parameters related to friction and heat transfer by lead-alloy coolant and identification of specific issues, either in modelling and/or in loop testing. The Heavy Eutectic liquid metal Loop for Integral test of Operability and Safety of PEACER (HELIOS) which is constructed in Seoul National University of Republic of Korea in 2005 is considered for benchmarking purposes. The 12 m height loop is driven by natural convection induced by heating of the core at lower level of the loop and removing of the gained head at the heat exchanger placed in the upper part of the loop, see figure 1. In the natural convection case the pump is not activated. Bypass pipe is connected between core inlet and loop cold leg downstream of heat exchanger. The temperature values are measured at different location of the loop. Mass flow rate is also measured. Steady and unsteady operation conditions and data are generated.

In the current study results obtained by CFD and system codes are presented. Different heating modes in the core are simulated by CFD in order to demonstrate the importance of location of heat deposition in the loop. The various CFD results obtained for the core are compared to benchmark results obtained by different system codes. This validates the used heat transfer and

pressure losses correlations of the system codes. Based on these data the thermal hydraulics investigation of the heat exchanger is assessed. The comparison of benchmark data to numerical data shows good capability of the used simulation tools for the studied natural convection case.

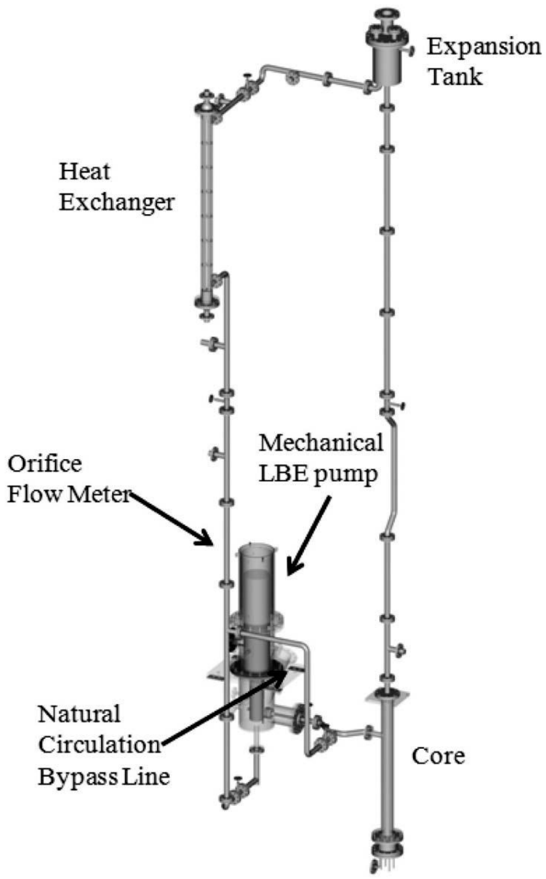

Figure 1. HELIOS Loop, Showing Main Loop Components