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METERO-V experimental set-up: presentation and first results. Uniform flows through a 8x34 PWR-type rod bundle with mixing grids at Reynolds number ranging from 800 to 70000: pressure loss measurements

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Abstract – We present the METERO-V set-up and preliminary results from the first set of experiments performed. METERO-V is a closed loop, equipped with a test section made of two halves of PWR-type rod bundles (8x34 rods) at full scale. The set up allows independent injection of different flow rates and temperatures at the inlet of each half of rod bundles. METERO-V experimental program focuses on IBLOCA (Intermediate Break Loss of Coolant Accident), SBLOCA (Small Break) and SLB (Steam Line Break) situations where significant 3D effects may occur in the core, with the aim to develop models and to validate them in a separated-effect way for CFD to system thermal-hydraulic scales. We present the preliminary results for a homogeneous inflow, varying the Reynolds number from laminar regime to fully turbulent regime. We measure pressure loss along the flow, across the grids and for the bare bundle. The axial pressure drop is successfully compared with available literature models and experimental data. Reproducibility and accuracy of the measurements is also very good. Future work will consist in non-symmetrical injections: velocities and/or temperatures.

I. INTRODUCTION

Component scale and system-scale thermalhydraulics codes have 3D models to assess the 3D effects during several accidental scenarios such as Large Break, Intermediate Break, Small Break- LOCA, or low flow rate SLB (Steam Line Break). During these accidents, the flow is mainly vertical in the core but the heterogeneous power distribution may create crossflows. The models that represent these situations have been validated through several experimental programs such as UPTF, SCTF or CCTF facilities. Nevertheless, this experimental database do not cover all conditions in terms of flow inclination, Reynolds number or pitch-to-diameter ratio of a PWR core in the studied situations. METERO-V (V for vertical) program is part of the NEPTUNE project, including CEA, EDF, Framatome, and IRSN. This extended abstract is dedicated to introduce the METERO-V experimental facility and its instrumentation. Preliminary results of pressure drop measurements are also provided.

II. FACILITY DESCRIPTION

METERO-V is a 20 m³ water loop, the fluid used is softened water at ambient temperature. In the test section the maximum pressure is 2.7 bar and the temperature goes from 10 to 50 °C. The test section contains two unheated halves rod bundles. The experimental facility imposes the boundary conditions for each half rod bundle in terms of

flow rate and temperature. Several flow regimes are achievable by METERO with Reynolds number from 800 to 70 000.

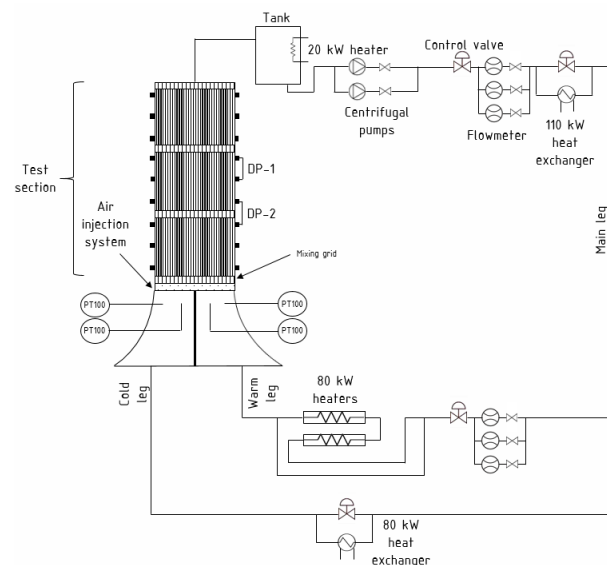


Fig. 1 : METERO-V schematic view

The design of METERO-V permits to perform flow rate dissymmetries. The flow rate in each leg is imposed thanks to the regulation valves and the flowmeters. Furthermore, METERO-V is also built to perform temperature

dissymmetries. The cold leg is made up of a heat exchanger that can disperse up to 80 kW of energy, while the warm leg provides an 80 kW heating power input. The experimental setup can produce a temperature dissymmetry between the two rod bundles of up to 40 °C depending on the flow rate. The temperature measurements are performed by PT100 probes. METERO-V is also capable to generate in the test section a two-phase flow due to the air injection at the bottom of the test section. All of these elements are displayed on the schematic view of the METERO-V thermalhydraulic loop (Fig. 1). The test section is rectangular with a dimension of 435x106x1789 mm. It is composed of two unheated halves rod bundles made of four mixing grids used in French PWR and 8x34 rods. The hydraulic diameter D_h of this geometry is 11.6 mm. The geometrical parameters of the test section geometry are listed on the Fig. 2.

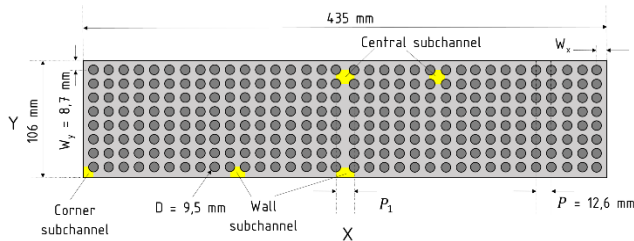


Fig. 2 : Test section geometrical parameters

III. RESULTS

Nine pressure taps are available on each small side of the test section. Their localization allows the measurement of bare rod bundle pressure drop (DP-1 on Fig. 1) and mixing grid pressure drop (DP-2 on Fig. 1). Rosemount 2051C and 3051C are used to perform the pressure drops measurements. Their scale of measurements are ± 620 mbar, ± 62.2 mbar and ± 7.3 mbar. The uncertainties associated to the instruments are listed in the Table I.

TABLE I

Uncertainties of measurements

Parameter	Associate uncertainty
Pressure drop ΔP	0.2 % of full scale of measurement
Velocity v	$1.41 \times 10^{-2} v$
Length of measurement L	2 mm
Density ρ	Considered negligible

From the data measured, the bare rod friction factor is deduced. The bare rod friction factor is defined as:

$$f = \frac{\Delta P}{\frac{1}{2} \rho v^2 \frac{L}{D_h}} \quad (1)$$

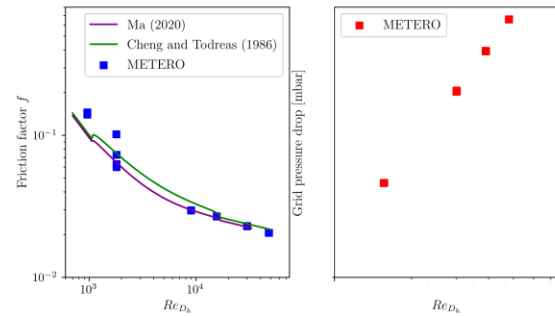


Fig. 3 : Friction factor of the bare rod bundle region (left) and absolute grid pressure drop (right) against the Reynolds number

The bare rod friction factor is compared to the Cheng and Todreas model [1] and the Ma et al model [2] from the literature. There is a good agreement with the models for the highest Reynolds numbers, but there is a difficulty to perform low Reynolds number measurements due to the small values of pressure drops encountered of around a few Pascal. The mixing grid pressure drops do not have absolute values due to the confidentiality of their geometry.

IV. CONCLUSIONS

This extended abstract presented the preliminary results of the METERO-V experimental facility in terms of pressure drop measurements. The results showed a good agreement with the literature, further work needs to be done to improve the METERO-V model especially for laminar flows. Furthermore, the characterization of the velocity fields inside the rod bundle will be done with PIV for uniform and dissymmetrical velocity inlets.

ACKNOWLEDGMENTS

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