EXPERIMENTAL STUDY OF THE ONSET CONDITIONS FOR
CROSS-FLOW THROUGH THE GAP BETWEEN TWO HALF RODS

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ABSTRACT

The enhancement of heat transfer from fuel rods to coolant of a Liquid Metal Fast Reactor (LMFR) decreases the fuel temperature and, thus, improves the safety of the reactor. One of the mechanisms that enhance heat transfer consists of large coherent structures that can occur across the gap between two adjacent rods. This work is a preliminary investigation of the flow between two curved surfaces, representing the gap between two fuel rods in a fuel assembly. The aim is to provide a reliable benchmark on the flow in such geometry, to investigate the presence of the aforementioned coherent structures and to investigate the applicability of Fluorinated Ethylene Propylene (FEP) as Refractive Index Matching (RIM) material for optical measurements.

The experiments are conducted on two half-rods of 15 mm diameter opposing each other inside a Perspex box with Laser Doppler Anemometry (LDA) to measure the velocity components. Different channel Reynolds numbers between $Re = 600$ and $Re = 30,000$ are considered for each $P/D$ (rod pitch-to-rod diameter ratio).

For high $Re$, the stream wise velocity root mean square $v_{RMS}$ between the two half rods is higher near the walls, similar to common channel flow. As $Re$ decreases, however, an additional central peak in $v_{RMS}$ appears at the gap centre, away from the walls. The peak becomes clearer at lower $P/D$ ratios and it also occurs at higher flow rates. Obviously this central peak in the $v_{RMS}$ cannot be attributed to turbulence only. Periodical behaviour of the span wise velocity across the gap is revealed by the frequency spectrum and the frequency varies with $P/D$ and decreases with $Re$.

TU Delft, as partner in the EU SESAME project, will provide an experimental benchmark to support the development of new numerical approaches to reproduce the thermal hydraulics of Gen-IV LMFRs.

KEYWORDS

Coherent structures, rod bundle, cross-flow, Laser Doppler Anemometry.

1 INTRODUCTION

Large periodic coherent structures have been detected by many researchers in flows through rod bundles geometries resembling the fuel assembly of LMFRs, PWRs, BWRs and CANDUs. These structures develop on both sides of the gap between two rods, forming the so-called gap vortex streets [1], causing a lateral flow across the gap (cross-flow). In a nuclear reactor cross-flow improves the heat exchange between the nuclear fuel and the coolant, decreasing the