NOTES

A THERMAL TRACING TECHNIQUE

N. SILIN†, L.E. JUANICÓ‡ and D.F. DELMASTRO*

† *Grupo Thermohidráulica, Centro Atómico Bariloche, 8400 Bariloche, Argentina*
silin@cab.cnea.gov.ar

‡*CONUAR S.A., Centro Atómico Ezeiza, B1802AYA Ezeiza, Argentina*
ljuanico@pecom.com

**Grupo Thermohidráulica, Centro Atómico Bariloche, 8400 Bariloche, Argentina*
delmast@cab.cnea.gov.ar

***Abstract* --- A new thermal trace method is developed and tested in a water loop. Different measurements have been carried out to map the tracer concentration at a selected cross section downstream from the trace input location. Also bulk temperature increase was measured showing good agreement with the values calculated by energy balance. The method proposed gave meaningful information about the flow, opening the possibility of its application to the measurement of mixing rates between connected subchannels.**

***Keywords*--- thermal trace, water flow, mixing rate**

I. INTRODUCTION

Most nuclear reactors are fueled by assemblies of parallel fuel rods called fuel elements (FEs). The FEs are cooled by refrigerant flowing axially within the interconnected spaces between the fuel rods (subchannels). The thermal-hydraulic safety margin and the operation limits are often defined using computer codes that state conservation of mass, energy and momentum in each subchannel and implemented trough computer codes (COBRA, ASSERT, VIPRE). These codes require that the mixing rate between coupled subchannels, or a suitable correlation in terms of subchannel parameters, be known beforehand and provided to the code.

It has been shown that the mixing rates between subchannels connected by narrow gaps, as it is often the case, are dominated by large-scale, cuasi-periodic coherent structures (Hooper and Rehme, 1984). For this reason numerical simulations involving simple isotropic turbulence models do not provide realistic mixing rates, being necessary to perform expensive tests in sophisticated thermo-hydraulic facilities for each new FE design.

A variety of tracers have been used in flow study in order to have an insight of the transport mechanisms and, in confined or sub-channel flow, to quantify mixing rates (Bell and Le Torneau, 1960, Renksizbulut and Hadaller, 1986, Tong and Weisman, 1996, Kawahara *et al.*,1997).

Flow visualization in gas flows, particularly for aerodynamic studies, is achieved using different fumes. Ink, electrolitically generated gas bubbles, different solid particles, etc., have been largely used for the same purpose in water flows. Measuring mixing rates between coupled subchannels does not require a visible tracer but involves measuring the amount of tracer effectively introduced in the flow as well as its concentration at the point of interest. Ion solutions for water flows, and chemically active gases for air flows have been largely used and work well, though these measuring systems are rather time consuming and expensive. Measurement of mixing rates through integration of local measurements (Laser Doppler Anemometry or Hot Wire Anemometry) is possible but available technology imposes serious restrictions on geometries and dimensions of the test section (Shen *et al.*,1991). These methods also do not provide subchannel-wise information, that is better suited for subchannel-oriented models, but it has to be calculated by numerical integration.

To be able to use some kind of trace to measure mixing rates and to get flow information we first need an element that introduces a measurable quantity of the trace in the flow in a reduced area, without interfering with the flow. Furthermore the trace so generated has to be measurable with a sensor (or a sensing system) not too intrusive.

Temperature can be used as trace; actually it would be the natural trace to use in thermo-hydraulic studies. In spite of this, the use of thermal traces is not widespread, there have been attempts to use thermal tracers in air flows with very interesting results, but because the temperature of the air is very sensible to any heat exchange, this method is only suitable for local measurements (Guellous and Tavoularis, 1992).

In this work we developed a thermal tracing technique for water flows that compromises an electrical superficial heater, introducing a localized thermal trace, and a temperature sensing system as means to measure the thermal trace "concentration" distribution.

The technique was tested in a simple test section in order to study the technological feasibility. The heat trace "concentration" distribution was measured under