OECD/NEA Sponsored CFD Benchmark Exercise: Turbulent Flow in a Rod Bundle with Spacers

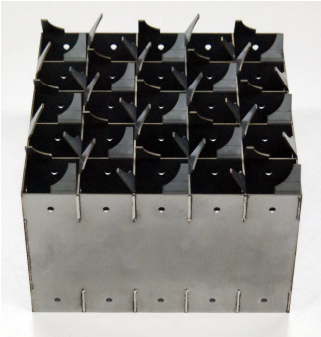
Invitation to Kick-Off Meeting

NEA Headquarters, 12 boulevard des Iles
Issy-les-Moulineaux, Paris, FRANCE

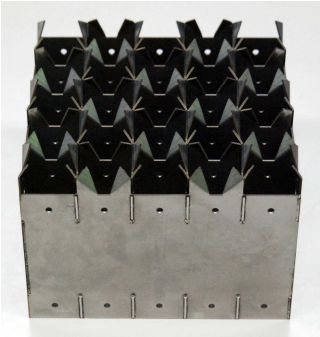
28 April, 2011

Background

The spacer grids that support the fuel rods in a nuclear reactor core also act as turbulence-enhancing devices to improve the heat transfer from the hot surfaces of the rods to the surrounding coolant stream. The design of the spacer grids is therefore an important optimization parameter for reactor vendors. Traditional approach to spacer design by experiments is now being supplemented by Computational Fluid Dynamics (CFD). But what are the best modelling options to capture the essential features of the turbulent structures downstream of the spacer, and ultimately the heat transfer mechanism?



Split-Type Spacer



Swirl-Type Spacer

The increasing maturity and trustworthiness of CFD software, coupled with spectacular advances in computer hardware, means that the technology can be employed by industry on a cost-effective basis in any design strategy, but must always be underpinned by suitable validation tests to measure the quality of the numerical predictions. Spacer grid designs are highly proprietary, and so the extent of appropriate validation data available to the CFD modelling community is severely limited.

A Blind CFD Benchmark Exercise

In March 2011, a cold rod 5x5 bundle test is being performed in the MATIS-H facility of the Korea Atomic Energy Research Institute (KAERI) in Daejeon, S. Korea. Data from this test have been reserved specifically for this CFD benchmark exercise, and will be kept secret for its duration.

CFD SIMULATIONS ARE INVITED

Participants in the exercise will be given details of the test geometry (flow channel, rod array and spacer grids), operating conditions (boundary conditions at the channel inlet) and upstream parameters. Both split-type and swirl-type spacer designs will be featured in this benchmark. **To aid mesh construction, CAD files of the spacer designs will be made available.** Following numerical simulation, participants will supply to the organizers results in the form of lateral (cross-stream) and axial velocity components, and turbulence intensity profiles at specified locations downstream of the spacer.

A synthesis of the results, including comparisons against measured data, will be carried out, and reported in the form of a Keynote Lecture at the forthcoming OECD/NEA–IAEA Workshop CFD4NRS-4, which will take place at the Daejeon Convention Center in the fall of 2012. Participants will have the opportunity to present their work in the form of a dedicated Poster Session at this workshop.

Those wishing to participate in the benchmark exercise are requested to register their interest with the OECD/NEA Secretariat: Abdallah.AMRI@oecd.org, with a copy to Brian.Smith@psi.ch. All registered participants will receive:

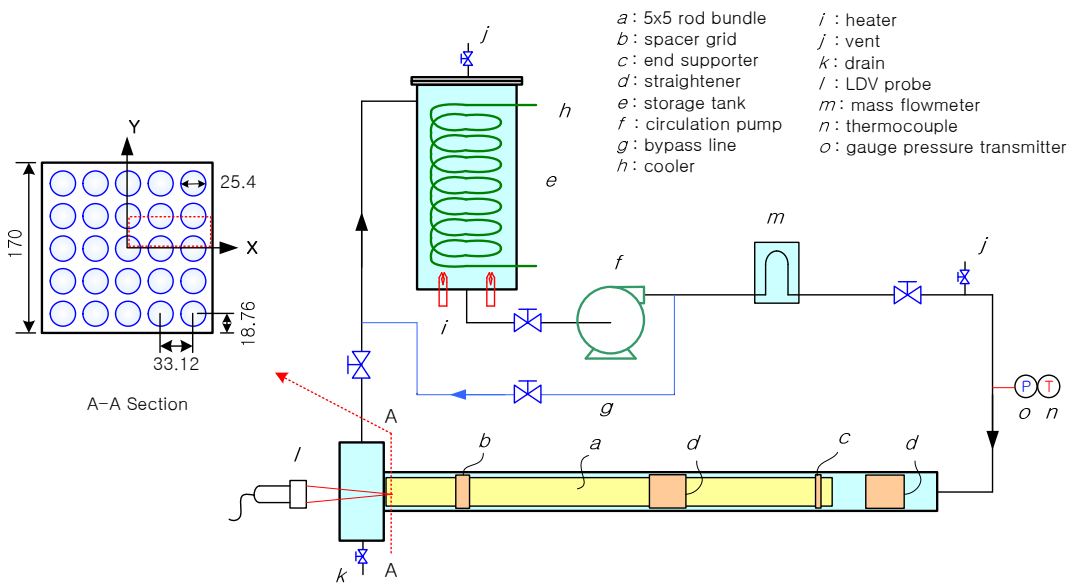
1. Further information and updates of the organization and progress of the benchmark activity;
2. A copy of the draft Benchmark Specifications, as soon as these are available.

The Specifications will be finalized at a **Kick-Off Meeting**, to be held at the NEA Headquarters in Paris, France on **Thursday, April 28, 2011**. Please register your attendance at this meeting in advance with the NEA Secretariat: Abdallah.AMRI@oecd.org, with a copy to Brian.Smith@psi.ch, so proper arrangements can be made. An agenda of the meeting will be circulated in due course.

The KAERI Rod Bundle Experiment

The experiment is conducted in a water circulation loop at ambient pressure and temperature. The test section comprises a square Plexiglas sub-channel of inner dimensions 170 x 170 mm containing a 5x5 rod bundle array over part of its length. To enable good visualization of the lateral flow structure between the rods, the test section is fabricated 2.6 times larger than the prototypic size of PWR fuel bundles. The total channel length is 4900 mm and the section containing the rod bundle arrangement 1700 mm. A 2-D LDA system is positioned end-on to measure the lateral velocities in the bundle at every point in the flow sub-channel. The axial velocity component is measured by changing the location of the LDA probe to the side of the test section. The rods are arranged in a square lattice: the rod diameter is 25.4 mm, the pitch is 33.12 mm, and the wall pitch 18.76 mm. The measuring points were closely distributed with a resolution of 0.75 mm.

Flow is maintained by a water storage tank and circulation pump. The tank contains a heater and a cooler to maintain constant temperature conditions during operation of the loop. The water flow rate is controlled by changing the pump speed: maximum discharge 2 m^3/min.



Schematic of the MATIS-H Test Loop

(MATIS-H: Measurements & Analysis of Turbulence in Subchannels - Horizontal)

Preliminary Agenda of the Kick-Off Meeting

A detailed agenda is being compiled, but items to be included are:

- Plan of the Benchmark Activity — Brian L. Smith, PSI, Switzerland
- OECD/NEA requirements — Abdallah Amri, NEA, France
- Test Facility and Instrumentation — Chul-Hwa Song, KAERI, Republic of Korea
- Keynote Speaker — To be Announced
- Benchmark Specifications — Brian L. Smith
- Synthesis and Reporting Procedure — Chul-Hwa Song, KAERI, Republic of Korea
- Open Forum Discussion

Organising Committee

Brian L. Smith, Paul Scherrer Institute, Switzerland
Chul-Hwa Song, Korea Atomic Energy Research Institute, Republic of Korea
Dominique Bestion, Commissariat à l'Energie Atomique, France
Ghani Zigh, US Nuclear Regulatory Commission, USA
John H. Mahaffy, US Nuclear Regulatory Commission, USA
Abdallah Amri, OECD Nuclear Energy Agency, France (Secretariat)

Dates & Deadlines

April 16, 2011	Registration for Attendance at Kick-Off Meeting
April 28, 2011-	Kick-Off Meeting of OECD/NEA – KAERI Benchmark
June 10, 2011	Distribution of Final Benchmark Specifications by Organizers
April 30, 2012	Deadline for Receipt of Simulation Results
May 31, 2012	Latest Date for Open Benchmark Meeting & Release of Test Data
Sept. 30, 2010	Presentation of Synthesis at CFD4NRS-4 Workshop