WORKSHOP ON "EXPERIMENTS AND CFD CODE APPLICATION TO NUCLEAR REACTOR SAFETY (XCFD4NRS)"

EXECUTIVE SUMMARY

BACKGROUND

Computational Fluid Dynamics (CFD) is to an increasing extent being adopted in nuclear reactor safety analyses as a tool that enables specific safety relevant phenomena occurring in the reactor coolant system to be better described. The Committee on the Safety of Nuclear Installations (CSNI), which is responsible for the activities of the OECD Nuclear Energy Agency that support advancing the technical base of the safety of nuclear installations, has in recent years conducted an important activity in the CFD area. This activity has been carried out within the scope of the CSNI working group on the analysis and management of accidents (GAMA), and has mainly focused on the formulation of user guidelines and on the assessment and verification of CFD codes. It is in this GAMA framework that a first workshop CFD4NRS was organized and held in Garching, Germany in 2006.

Following the CFD4NRS workshop, this XCFD4NRS Workshop was intended to extend the forum created for numerical analysts and experimentalists to exchange information in the field of Nuclear Reactor Safety (NRS) related activities relevant to Computational Fluid Dynamics (CFD) validation, but this time with more emphasis placed on new experimental techniques and two-phase CFD applications.

SCOPE AND OBJECTIVES

The purpose of the workshop was to provide a forum for numerical analysts and experimentalists to exchange information in the field of NRS-related activities relevant to CFD validation, with the objective of providing input to GAMA CFD experts to create a practical, state-of-the-art, web-based assessment matrix on the use of CFD for NRS applications.

The scope of XCFD4NRS includes:

- Single-phase and two-phase CFD simulations with an emphasis on validation in areas such as: boiling flows, free-surface flows, direct contact condensation and turbulent mixing. These applications should relate to NRS-relevant issues such as: pressurized thermal shocks, critical heat flux, pool heat exchangers, boron dilution, hydrogen distribution, thermal striping, etc. Discussion of validation of the CFD tool, use of systematic error quantification and Best Practice Guidelines (BPGs) was encouraged and considered in the paper review process.

- Experiments providing data suitable for CFD validation, specifically in the area of NRS. These should focus on local measurements using multi-sensor optical or electrical probes, laser-doppler velocimetry, hot-film/wire anemometry, particle image velocimetry and laser induced fluorescence. Papers should include a discussion of measurement uncertainties.

CONCLUSIONS AND RECOMMENDATIONS

There were over 140 participants to the XCFD4NRS workshop to hear 5 invited talks, 3 talks on OECD-CSNI activity related to CFD, 44 technical papers, and to see 15 posters. This is about 40% increase with respect to the previous CFD4NRS held in Garching in 2006, and this confirms that there is a real need for such workshops. The objectives that 2/3 of the papers be concerned with two-phase issues and 1/3 dedicated to experimental techniques and CFD grade experimental data were reached.

USA was candidate to host a follow-up meeting, organized by US-NRC (confirmed by NRC a few days after the workshop). The suggestion received encouraging remarks from the audience during the discussion at the panel session. KAERI also proposed to host and organize a future workshop. A great majority of participants considered they would be interested in attending a follow-up workshop within two years.

Comments were made during the panel session on the content of XCFD4NRS. it was considered that some contributions were not directly related to the nuclear safety. Another comment suggested that such workshops should be a forum to discuss novel approaches but one must also keep in mind that the end users are people from the nuclear safety. There was a consensus on the need to keep a high quality of papers. It was also suggested to promote international benchmarks for CFD.

Both CFD4NRS and XCFD4NRS workshops proved to be very valuable means to assess the status of CFD code capabilities and validation, to exchange experiences in CFD code applications, and to monitor progress.

There was again an offer to publish selected papers from the workshop in a special issue of the Nuclear Engineering and Design (NED) Journal. It was also mentioned that the special issue devoted to CFD4NRS received a very high number of visits on the journal website and a lot of papers were downloaded. Session chairmen will make a selection of papers to be submitted to the NED Journal. It is anticipated that the special issue of NED dedicated to XCFD4NRS will appear early in 2009.

The following additional comments were made:

- Current capabilities of two-phase measurement techniques are still too limitative for CFD validation. Further efforts are required to develop more advanced techniques, such as X-ray PIV, and international cooperation is necessary to support the high cost of development.

- Most of CFD codes are commercial and do not offer a full transparency with access to sources, which may be a problem from a regulation point of view.

- Application of CFD to Nuclear Safety requires that code uncertainties are determined, as they are now for system codes.

The participants made the following recommendations:

- One should keep a close link between people developing experimental techniques and performing validation experiments, and people developing CFD models and codes.

- Best Practice Guidelines should still be promoted, which requires that they are further developed and made more specific to each application. For two-phase CFD the establishment of Guidelines on the choice of the physical models depending on the phenomena being investigated has to be considered as a long term activity.

- Experimental techniques should be further developed to provide CFD-grade data for validating CFD models, including estimates of measurement uncertainties.

- A new item should be added in the scope of the workshop: the development and application of uncertainty evaluation methods for CFD codes

Summaries of the technical sessions are given at the end of Technical Sessions. The organisational aspects and paper selection are outlined in Annex I, and the list of participants is given in Annex II.