

Enhancement of Lappeenranta instrumentation of nuclear safety experiments (ELAINE)

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Introduction

One of the main challenges in experimental research is to properly record the studied physical quantities from the tests for the use of the analysts as numerical data. In nuclear safety research this data is mostly used in validation purposes. The requirements for the quality of the test data for code validation have changed dramatically in the last few years, mainly due to more extensive use of CFD computation.

In order to ensure the availability of high quality data from the experiments, the ELAINE (Enhancement of Lappeenranta instrumentation of nuclear safety experiments) project was proposed for SAFIR2014 research programme to start in 2011. The main goal of the ELAINE project is to increase the quality and the quantity of the measured data produced by the Nuclear Safety Research Unit at Lappeenranta University of Technology (LUT) in order to meet the requirements imposed by today's CFD modeling.

Measuring capabilities

One of the main goals of the ELAINE project is to improve measuring capabilities by acquiring novel measuring devices. The applicability of sophisticated measuring devices has been studied during the first half of the project. Among these are Particle Image Velocimetry (PIV) and Wire Mesh Sensor (WMS) systems.

Particle Image Velocimetry (PIV)

A Particle Image Velocimetry (PIV) system was purchased and commissioned in 2011. The technical requirements of the PIV system were decided after the research staff had familiarized with similar PIV applications on a visit to Paul Scherrer Institut (PSI) in Switzerland in March 2011. Main components of the PIV system were received in late October 2011. The commissioning itself was carried out as a master's thesis work. The PIV system was first applied in the EXCOP project during 2012. The latest test series with the PPOOLEX test facility was carried out in January – February 2013.

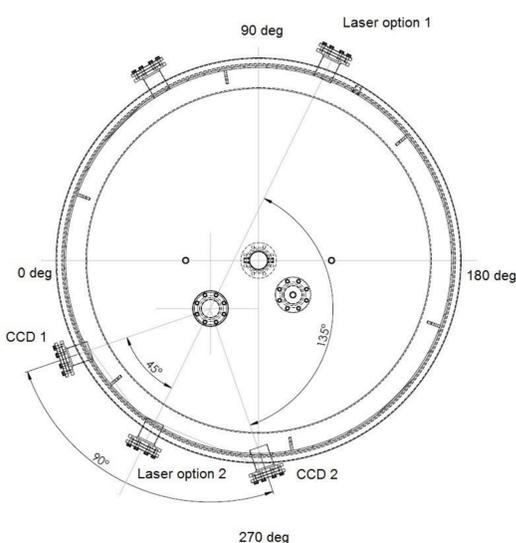


Figure 1. Positioning of the PIV system to the PPOOLEX test facility.



Figure 3. Placement of the laser to the PPOOLEX test facility.

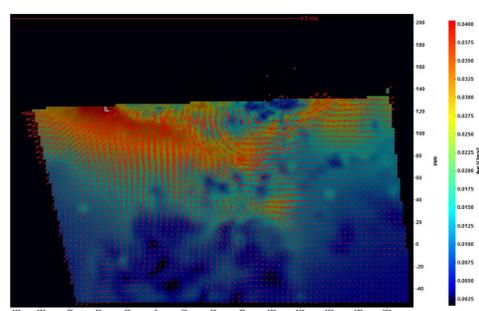


Figure 2. The averaged velocity vector field of the outflow phase in the vicinity of the blowdown pipe measured with PIV.



Figure 4. Placement of a camera to the PPOOLEX test facility.

Wire Mesh Sensor (WMS)

The applicability of a wire mesh sensor (WMS) and the availability of the components have been studied in respect of the usefulness for different purposes. The system can be used for measuring various quantities – such as void fraction – that are directly or indirectly related to electrical properties of the substance, such as impedance or conductance. The wire mesh sensor system can also be constructed in such a way that the temperature sensors between the two sets of wires can be used for temperature field measurements.

Based on the survey of wire mesh sensors, the wire mesh electronics unit was purchased from Teletronic Rossendorf GmbH in 2012. The electronics is capable of simultaneously acquiring the signals of two 128x128 sensors with temporal resolution of 1 ms. According to current plans, the use of the system starts in 2013 by applying the wire mesh sensor system in a separate simple low pressure test facility where the signal processing and other features can be tested. Later, sensors suitable for more challenging applications (in high pressure) can be purchased from manufacturers like Helmholtz Zentrum Dresden Rossendorf (HZDR), or construct by LUT after more experience has been gained.

Data storage and distribution software

The main goals of ELAINE project include also ensuring the availability of data storage and safe method for distributing the archived experimental data by developing an archiving software. The new database software called Experiment Data Storage (EDS) was opened for internal and external use in 2012.

Instruments, substitutive components and other devices

The aim of this subproject is to ensure operability of the test facilities in all conditions. The process control system used in the PACTEL and the PPOOLEX facilities has been installed and coded in a new platform. Components such as measuring units for the data acquisition systems, pressure and differential pressure transmitters, thermocouples and flow meters have been purchased partly as spare parts for reserve to prepare for component failures. Components have also been purchased to avoid the swapping of the devices from one test facility to another. Also devices that help and make the use of the new laboratory and the installation of the devices into the test facilities safer, have been bought.

Main circulation pumps for the PWR PACTEL test facility

In the plan for 2012 the goals of the ELAINE project were updated and the installation of the main circulation pumps to the PWR PACTEL test facility was introduced. The subproject aims at acquiring and installing the pumps to the facility. Equipment related to the pumps were identified, such as power feeds, drives, safety automation and mounting pedestals. Also the plans for the support structures and primary piping modifications are to be made.



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