STUDY OF TWO-PHASE AIR-WATER FLOW THROUGH SINGULAR GEOMETRIES AND SAFETY VALVES

Vasilios Kourakos, Greece
Supervisors: Prof. J.-M. Buchlin & Prof. P. Rambaud
Promoter: Prof. J.-M. Buchlin (Université Libre de Bruxelles, Belgium)

The use of pressure relief systems such as rupture disks, control and safety valves is of major importance in the nuclear and chemical industry. These devices are originally designed to work in a single-phase flow regime (liquid or air). However, when this apparatus is working under two-phase flow conditions, the prediction of the local pressure and flow behavior is not straightforward. Additionally, the mass flow control can be influenced by the presence of the second phase. Therefore, a thorough study of this subject that could lead to the proper sizing of the valve seems really appealing. Although there is a lack of papers found in literature dealing with this kind of problem, some authors like Diener & Schmidt (2004), Boccardi et al. (2005) and Lenzing et al. (1998) have investigated the flow through safety valve and adopted methods to calculate the dimensioning of this device.

In this project, two experimental loops are built; one in large scale in the French company CETIM and one in smaller scale in VKI. These two setups allow pressure, flow rate measurements and flow visualization along a horizontal straight pipe with several types of singularities. PIV measurements in single-phase flow are performed in a divergence section. The void fraction, bubble size and velocity is also measured with optical probe upstream and downstream the singularity. An example of such measurement is presented in Figure 1 for the case of a smooth enlargement of σ=0.64 (DN32/40). The vertical void fraction distribution is plotted versus radial position in the tube upstream and downstream the singularity. A rich experimental database is extracted with the purpose of validating the CFD computations performed in several singularities.

The aim of studying different singular geometries is to draw some useful conclusions for the behavior of a safety valve working in two-phase flow; the complex geometry of this device can be considered as a sum of different simpler singularities. Therefore, a transparent model of a safety valve, made in Polymethyl Methacrylate (PMMA), is built and will be tested under single (water or air) and two-phase (air-water) flow conditions. Figure 2 shows a schematic of such a valve. The pressure will be measured upstream, downstream and inside the core of the valve. The full optical access allows flow visualization with the purpose of identifying the flow regimes formed inside the valve. Additionally, the void fraction, bubble size and velocity will be measured upstream and downstream the valve. The lift of the valve will be predicted and compared to the nominal value given by the manufacturer. The aforementioned measurements will be useful for drawing some conclusions for the better design of such a device.

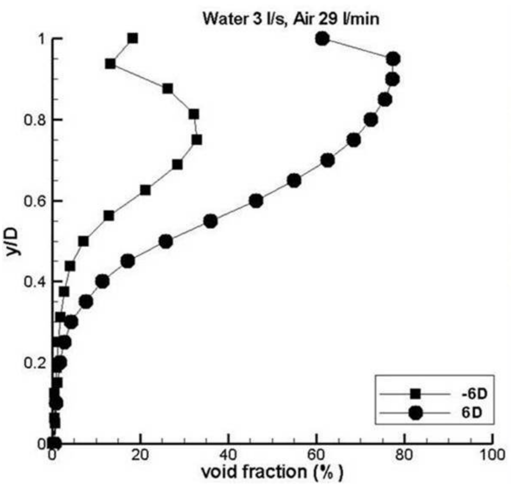

Figure 1: Effect of the singularity on the void fraction distribution (vertical profile) in a divergence section of σ=0.64 (DN32/40)

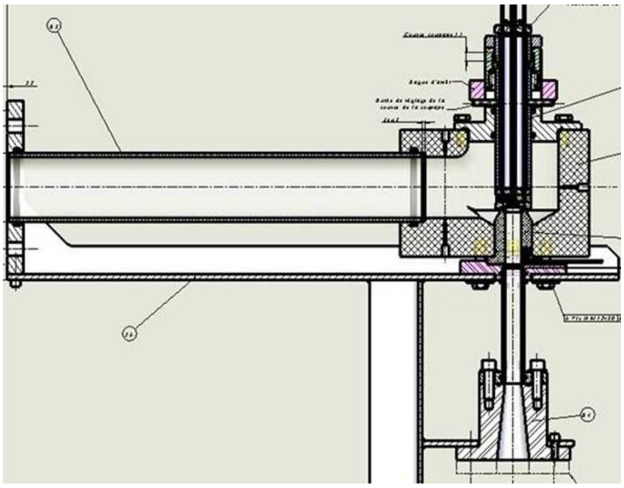

Figure 2: Drawing of the transparent model of a safety valve of dimensions DN20/DN80 (inlet/outlet diameters) made in PMMA