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30 minutes

Experimental and numerical investigation of the air-entrainment process within hydraulic strutures

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Resume (Kurzfassung)

The air-entrainment, also known as self-aeration process, is one of the most ubiquitous phenomenon that occurs in turbulent free-surface flows. In general, the air-entrainment occurs when the free surface becomes turbulent, i.e. when the turbulent boundary layer reaches the surface, allowing the entrance of high quantities of air (usually in form of bubbles) into the water body (Figure 1). In turn, the entrained air increases the flow volume and changes the main characteristics of the air-water mixture, such as compressibility, density, and the turbulent structure.

Air-entrainment phenomena plays an important role in the hydraulic engineering design. For example, controlled aeration is often used in spillways to protect the structure from cavitation damage but it is also used to dissipate the energy of the flow, avoiding further damage at the river bottom downstream of the dam. In the case of urban drainage systems, the air-entrainment carried inside of drainage elements, such gullies and manholes, can be responsible for its efficiency decrease (Figure 2).

With the advent of high-performance computers and the development of more robust and accurate Computational Fluid Dynamics (CFD) models, like OpenFOAM™, the hydraulic engineers have now a sophisticated tools to predict flow fields. In case of air-water flows, whenever a sharp interface is possible to be defined, most CFD models can be a reliable tool and provide excellent results. However, this is not the case where air-entrainment occurs and air-concentration becomes significant. In fact, the mixture processes and the interactions forces between the air bubbles and the water phase are not well simulated besides the increase of computational time and the need for more fine meshes.

New techniques to predict the air-entrainment need to be developed, tested and included on the free and open-source OpenFOAM™ CFD toolbox. In order to achieve that, experimental tests in physical models, such as in gullies, manholes (Figure 3) and stepped spillways, are being carried at the Universities of Coimbra, Sheffield and FH Aachen in order to validate the numerical results from the new techniques. This work is a part of a PhD research at the University of Coimbra with the collaboration of the Dr. James Shucksmith (University of Sheffield), Prof. Daniel Bung (FH Aachen and Prof. Gavin Tabor (University of Exeter).

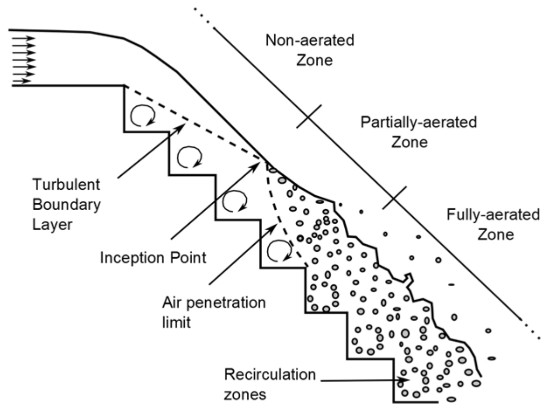

Figure 1: Scheme of Air-entrainment over a Stepped Spillway.

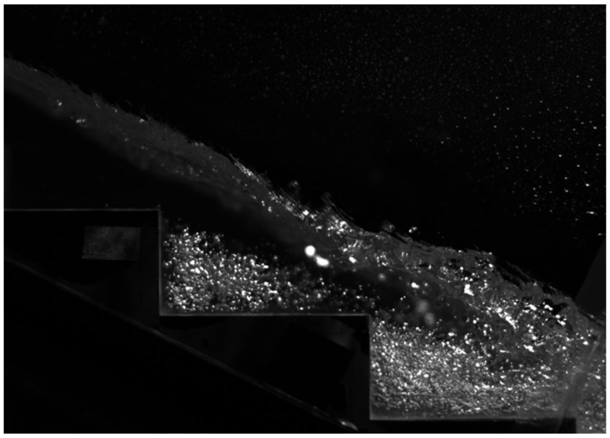

Figure 2: Air-entrainment at the inception point.

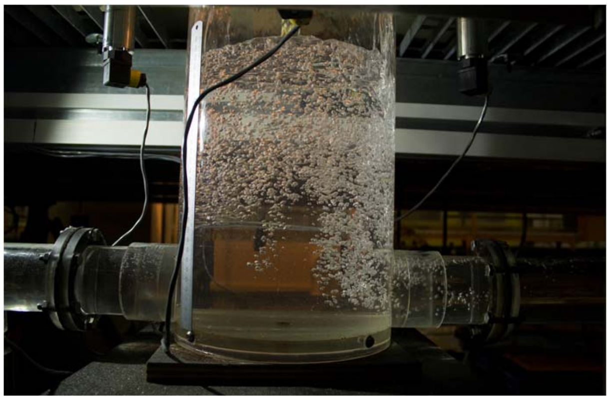

Figure 3: Air-entrainment within an UK circular-design manhole.

Profile (Zur Person)

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Literature

Lopes, Pedro. 2013. "*Free-surface Flow Interface And Air-Entrainment Modelling Using OpenFOAM*". Thesis Project of Doctoral Program. DECFCTUC, Coimbra, Portugal.

Lopes, P; Leandro, J; Carvalho, RF; Páscoa, P; Martins, R. 2013. "*Numerical and experimental investigation of a gully under surcharge conditions*", Urban Water Journal, DOI:10.1080/1573062X.2013.831916

Application (Anmeldung)

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