Ministero dell'Istruzione, dell'Università e della Ricerca
UNIVERSITY OF SALERNO

Department of Civil Engineering

Ph.D. Thesis
in
Risk and Sustainability in Civil, Architectural and Environmental Engineering Systems

Cycle XXXIII (2017-2020)

ABSTRACT

OPTIMIZATION OF WATER TREATMENT PROCESSES USING COMPUTATIONAL FLUID DYNAMICS

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The research project has been funded by National Research and Innovation Operational Program 2014-2020, European Social Fund, Action I.1 "Innovative Doctorates with Industrial Characterization"

Optimization of wastewater treatment plants include different aspects of water treatments such as the development of mathematical models, the parametric setting and related sensitivity analysis.

Computational Fluid Dynamics (CFD) consists of a set of methods for solving Fluid dynamic problems, including WWTP process units whose complexity can be reproduced, yielding hydrodynamic and biological process fields.

CFD application involved mainly the study of fluid flow for civil and industrial applications, heat and mass transfer problems in aeronautics, vehicle aerodynamics, chemical engineering, nuclear design and safety, ventilation and industrial design but, due to the lack of advanced numerical models and limited computing power, the results were not accurate.

In this work the feasibility and functionality of a modelling approach to decrease the Energy consumption and improve the efficiency of the processes in some WWTP units was assessed. Four case studies were conducted, each of them related to a specific process unit.

In the first study two different mixing systems in an Anaerobic Digester were compared to evaluate the best mixing mechanism, as well as the energy consumption. As result the preferable was the Gas mixing approach rather than the mechanical mixing, in terms of mixing efficiency and energy consumption.

In the second case, the critical regions in a disinfection tank were identified, comparing on site measurements with the simulation model outputs. Indeed, the slow velocity areas correspond to the sections of the tank with a high PPA concentration. Consequently, non-homogeneous PPA mixing in the tank was observed. It has been found that the limit of this process is given by the low contact time to promote the reaction between acid and water.

The efficiency of the Sedimentation tank was assessed in terms of deflector`s geometry. It has been proven that the Densiometric Froude number (FD) is an indicator suitable to optimize the design of the deflector, indeed with an FD number equal to 1 the best configuration to achieve a lower dispersed solid concentration in the clarified outlet arises.

The last study concerned the oxygen distribution and outlet time of an Oxygenation Tank. The energy consumption and the efficiency has been determined in terms of pumps operating interval. The obtained operating interval is 240s with a pumps shutting time of 40 seconds. As output of the research was assessed that turning off the pump 40 s each cycle gives an estimated energy saving of 10%. However, the shutting time could affect the biological processes that take place in the tank. The oxygenation tanks are designed to promote aerobic processes, but the shutting time could decrease the oxygen concentration up to activate the anaerobic processes.

The treated aspect of the above mentioned studies highlights the use CFD as a design/checking tool. The use of CFD in WWT processes turned to be the most promising approach being able to simulate complex processes bringing reliable results with affordable costs.