Pump and Ejector Design in Wastewater Treatment Pilot Equipment

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Abstract

Introduction: Generally, wastewater treatment plant is composed of three parts: primary (physical), secondary (biological) and tertiary (refinement) operations. Specifically, tertiary treatments are carried out to reach a specific water quality following downstream treatments. In the case of textile industry, refining treatments are often required to adequately remove residual color, surfactants and salts. Ozone treatment is an oxidative process, specific to demolish the chromophoric bonds or groups in the dye molecules: it generates a very high de-coloration [1].

A useful method for adding the ozone gas into water and maximize ozone-water mixing to increase mass transfer, is the use of Venturi injectors.
Venturi injectors consists of a short length of straight tubing connected at either end to the pipe line by conical sections (Figure 1). Recommended proportion to minimized pressure drops are inlet angle $\alpha 1 = 21° \pm 2°$ and outlet one $\alpha 2 = 5°$ to $15°$ [2].

Forcing water through Venturi body, it creates a differential pressure between the fluid inlet and outlet, which in turn creates a vacuum inside the injector body. In this part, it is possible introduce ozone.

Use of COMSOL Multiphysics®: A 2D axisymmetric model has been used in order to determine the characteristic curve of the ejector (pressure drops) and the presence of vacuum in the straight tubing. The k-ε turbulent flow model was used in COMSOL Multiphysics®; this allows to use Navier-Stokes equations for conservation of momentum and the continuity equation for conservation of mass. Turbulence effects are modelled using the standard two-equation k-ε model with realizability constraints. Flow close to walls is modelled using wall functions. The liquid flow was considered incompressible.

As boundary conditions, the inlet velocity was set in a range of 1 to 2.7 m3/h and the outlet was set to atmospheric pressure. The characteristic curve of the plant is given by the ejector. In this way, ejector diameter and outlet angle $\alpha 2$ have been change to define the characteristic curves.

Results: The results of the simulation are the ejector characteristic curves (depending on the diameter and angle) and the evaluation of the vacuum in the straight tubing.

In the graph (Figure 2) are reported three pump characteristic curves corresponding to Lowara 3

SV pump with 4, 6 and 8 stages. The desired working conditions (outlet pump pressure and flow rate) are been defined thanks the intersection between the ejector and pump characteristic curves. Ejector parameters (diameter and $\alpha 2$) and pump type are chosen comparing their characteristic curves.

The best performing ejector have the following characteristics: 2mm diameter and $\alpha 2 = 8°$. Instead, the 8 stages pump is the best in reference to the chosen ejector for the interest working conditions.
The vacuum in ejector straight tube was formed in all the simulations.

Conclusions: The study has brought to define the design parameter of the ejector. The working condition (pump outlet pressure and flow rate) definite by simulation was validated in the pilot equipment.

Reference

[1] K. Turhan, Z. Turgut, Decolorization of Direct Dye in Textile Wastewater by Ozonization in a Semi-batch Bubble Column Reactor, Desalination, 242(1), 256-263 (2009)
[2] R. Perry, D. Green, Perry's Chemical Engineers' Handbook, 5th edn., 5-12 to 5-13 (1973)

Figures used in the abstract

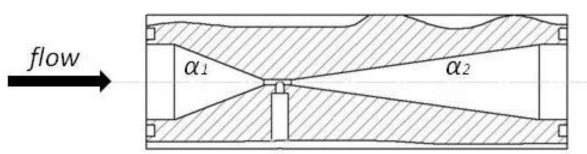

Figure 1: Venturi ejector scheme.

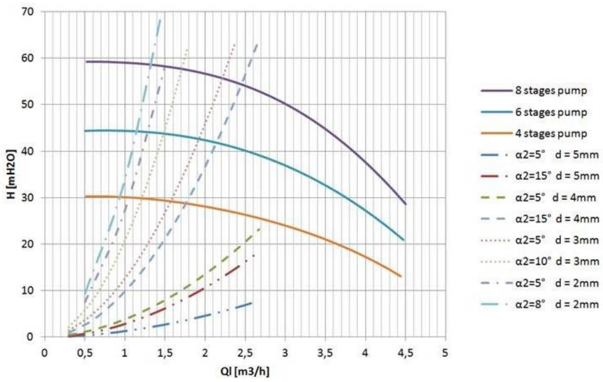

Figure 2: Pump and ejector characteristic curves.