Pump and ejector design in wastewater treatment pilot equipment

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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 colour, surfactants and salts, to reach quality specifications for process water recycling.

Ozone treatment is an oxidative process, specific to demolish the chromophoric bonds or groups in the dye molecules: it generates a high efficiency de-coloration [1].

A method for intensifying the ozone transfer into water and maximize ozone-water mixing is provided by Venturi ejectors. Venturi ejectors consists of a short tapered pipe section which ends in a throat and then a second conical section is designed with a smaller angle (Figure 1). Recommended proportion to minimize the net pressure drop are inlet angle \( \alpha_1 = 21° \pm 2° \) and outlet one \( \alpha_2 = 5° \) to 15° [2].

Forcing water through a Venturi system a moderate pressure drop between the inlet and the outlet, and, according to Bernoulli principle, generate a minimum pressure in the throat section, thus having the possibility to suck in another fluid, either liquid or gas, the oxygen/ozone mixture in this specific case.

Comparing experimental and simulated data. In Figure 3 three pump characteristic curves corresponding to Lowara 3 SV pump with 4, 6 and 8 stages are reported. The desired working conditions (outlet pressure and flow rate) are defined by intersecting the ejector and pump characteristic curves. Ejector parameters (diameter and \( \alpha_2 \)) and pump type are chosen comparing their characteristic curves.

![Figure 1. Venturi ejector scheme](image1)

![Figure 2. Schematic plan representation: A - pump, B - Venturi ejector](image2)

Computational Methods
A 2D axisymmetric model has been used in order to determine the characteristic curve of the ejector (pressure drops) and the generation of a low pressure in the throat section. The \( k-\epsilon \) turbulent flow model was set in COMSOL; this allows to use Naveier-Stokes equations for conservation of momentum and the continuity equation for conservation of mass. Turbulence effects are modelled using the standard two-equation \( k-\epsilon \) model with realizability constraints. Flow close to walls was modelled using wall functions. The liquid (water) was considered incompressible.

As boundary conditions, the inlet velocity was set in a range of 0.036 to 1.296 m/s (in term of volume flow rate in a range from 0.13 to 2.7 m³/h) and the outlet was set to atmospheric pressure.

The characteristic curve of the system is fundamentally given by the ejector. The ejector diameter and outlet angle \( \alpha_2 \) were changed to define the characteristic curves (\( \alpha_1 = 21° \)).

To compare experimental and simulated data, equivalent sand roughness height was imposed to the model.

Results
The results of the simulation provide the ejector characteristic curves as a function of geometric parameters and the evaluation of the pressure value in the ejector throat. Moreover, the equivalent sand roughness height is defined.

Conclusions
The study was demonstrated useful to define the design parameter of the ejector. The working conditions (pump outlet pressure and flow rate) given by the simulation based on equivalent sand roughness were validated in the pilot equipment.

References