Linear Chemical Dose Controller

August 14, 2011

Abstract

The linear chemical dose controller, LCDC, is a key technology for AguaClara. The LCDC makes it possible for the plant operator to directly set the chemical dose for the coagulant. The LCDC is a combination of several technologies and although the AguaClara team has been developing these technologies since 2004, there is still a critical need to improve the performance and accuracy of the LCDC. The immediate priority is to build dose controllers for our target design flow rate of 2.5 $\frac{mL}{s}$ and test the calibration procedure.

Creating a linear chemical dose controller that can be directly controlled by the plant flow rate has been a major accomplishment of the AguaClara team. This invention is now almost ready for deployment. We need detailed instructions for obtaining parts, fabricating the components, placing the unit in a water treatment plant, calibrating the doser, and using the doser. We also need to write a paper documenting the theory and design of the dose controller.

students	3
skills	fluid mechanics, fabrication, experimental methods, data analysis

1 Introduction

The LCDC performance has not been as good as expected due to unexpectedly high minor losses that are not proportional to the flow rate (figure 1). This nonlinear dependency causes an error in the dosing that can become quite large when minor losses become significant. This occurs for dosing tubes with a small $\frac{L}{D}$ratio or high flow velocities. The current recommendation is that the dosing tube be at least 1.85 m long with in inside diameter of 3.175 mm and a maximum flow rate of 2.5 $\frac{mL}{s}$. The requirement for a 1.85 m long straight tube for the LCDC makes it difficult to install in some locations and will make it difficult to retrofit existing plants. We need to separate the functions of creating a desired relationship between flow rate and head loss from the function of delivering the fluid to the slider. The flow relationship can be created with a specially designed tube located near the constant head tank. The flexible connection to the slider

Figure 1: Chemical dose controller as installed at Agalteca. The dosing tube is too short in this installation resulting in a nonlinear response.

on the lever arm can be made with a larger diameter tube that has negligible head loss.

Explore options for using two rigid tubes that are $1\,m$ and $0.85\,m$ long as the flow control tubes. The first tube would be connected to the bottom of the constant head tank and would be vertical. The bottom end of the $1\,m$ tube would connect to the $0.85\,m$ tube through whatever $180^{\rm o}$ has the lowest minor loss coefficient. The top end of the $1\,m$ tube would connect to a larger diameter flexible hose that carries the fluid to the slider. This system could easily be extended to multiple dosing tubes while still only using a single hose to carry the fluid to the slider.

The optimal method of reversing the flow direction could be a flexible tube that fits over the rigid tubes and hence is larger diameter or it could even be a gradual bend in the more rigid tubing. It should be possible to have the minor loss coefficient from the flow reversal approach the value of 2. If this minor loss is too large it would be possible to add more major loss by increasing the length of the rigid tubes and further reduce the velocity in the rigid tubes. The goal should be to keep the maximum dosing error below 10% for a plant flow rate that is 50% of design and for the lowest chemical dose. This is assuming the system is calibrated at the maximum chemical dose and maximum plant flow rate.

Additional tests for the LCDC are...

1. Test the entire system for chlorine resistance. The dosers that are used for chlorine all look terrible in Honduras because of small chlorine leaks. Propose improve plumbing connections that will completely eliminate leaks and be easy to clean and maintain.

2. Test the screw that fastens the slider to the lever. Will this screw wear out over time? Will it be damaged if alum, PACl, or chlorine is spilled on it?

3. Devise a method to generate labels for the lever arm using AutoCAD or some other method that can be automated and included with the design

files (coordinate with the design team).

4. Test and document the calibration method of a new LCDC so that it produces the design chemical dose.

5. Provide fabrication details on the wiki so that the LCDC can easily be built without requiring assistance from the Cornell team.

6. Evaluate best methods of distributing the LCDC technology. Should the LCDC be built by a small company and distributed globally, built by small companies in global regions, or built by local implementation partners?

7. Write an article for submission to Journal of Environmental Engineering that details the design of the LCDC including both theoretical and practical constraints.

References

[1] A. K. Mohanty and S. B. L. Asthana, Journal of Fluid Mechanics / Volume 90 / Issue 03, pp 433 - 447, 1978. Published online: 19 April 2006 DOI:10.1017/S0022112079002330

[2] Zhou, Y., & Shah, S. (2006). New Friction-Factor Corrections for Non-Newtonian Fluid Flow in Coiled Tubing. SPE Drilling and Completion , 68-76 (DOI:10.1017/S0022112079002330).