Fluid Flow Dynamics Visualization: User Manual

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December 8, 2012

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1 Preface

Fluid Fluid Dynamics Visualization is a particle filtration reactor simulator. This document describes the operations which can be performed in Fluid Flow Dynamics Visualization.

2 Introduction

Fluid Flow Dynamics Visualization allows you to simulate three different kinds of reactors; batch reactor, constantly stirred reactor, and plug flow reactor.

3 Installation

You can run Fluid Flow Dynamics Visualization by running FluidFlowApplet.jar as an executable, in the command line, or in a Java capable browser. To run as an executable, you should be running Java™ version 6 or higher. To run in the command line, type

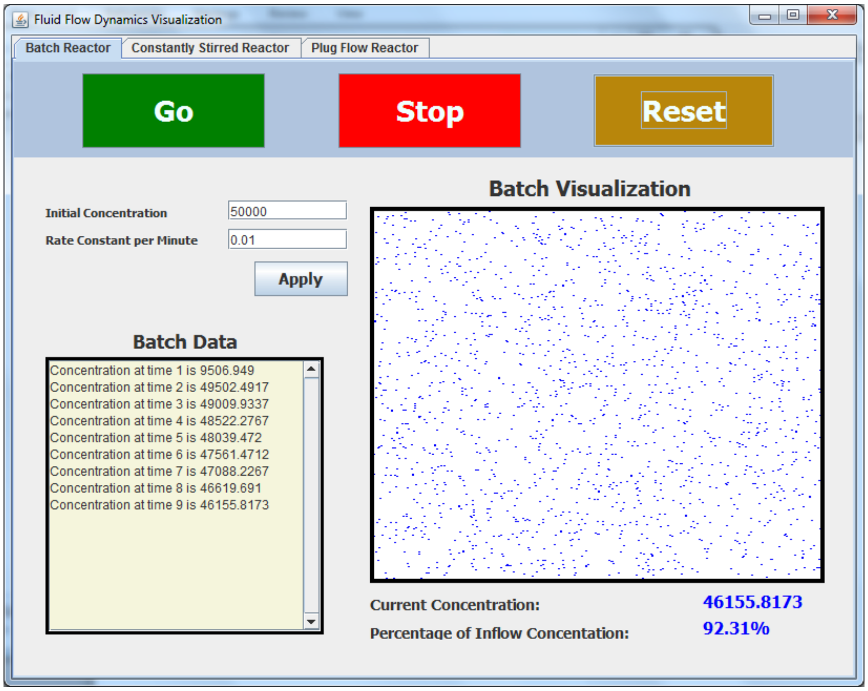
```
java -jar FluidFlowApplet.jar
```

To run in a web browser, the browser must have Java and JavaScript capable browser such as Internet Explorer, Firefox, Chrome, or Safari. If the browser is JavaScript enabled but does not have Java, the applet will give you a link to the Oracle download page.

4 Controls

Each reactor can be accessed by clicking on their respective tabs. Each reactor page allows you to start, stop, and reset the reactor simulation. The reset button, will set the reactor state to the starting state with the user set parameters given in the entry fields. Clicking reset while the reactor is running will cause the simulation to restart. The simulations will continue running until you click the stop button or close the program.

5 Batch Reactor

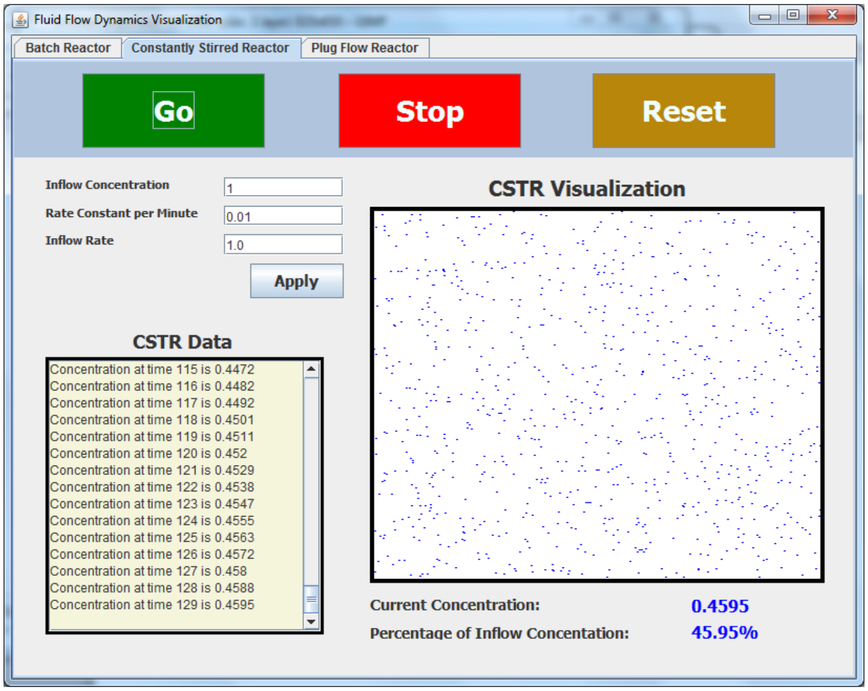


A batch reactor operates by putting a solution into the reactor, sealing it, and then allowing the reactor to filter the solution before removing the contents. Fluid Flow Dynamics Visualization allows you to simulate the change in particle that occurs in a batch reactor. The user can specify the initial concentration and reaction constant. See the Appendix for a description of the algorithms used in simulation.

The concentration per cycle is shown in the Batch Data dialog. The Batch Visualization dialog gives a pictographic representation of the change in particulate concentration. The change in particle concentration is shown visually by the density of dots in the simulation. The Current Concentration and the Percentage of Inflow Concentration, which is the current concentration divided by the initial concentration, are shown in the lower right of the window.

The initial concentration and reaction constant can be set by entering numerical values in their respective fields; “Initial Concentration” and “Rate Constant per Minute”, and then clicking the Apply button.

6 Constantly Stirred Reactor

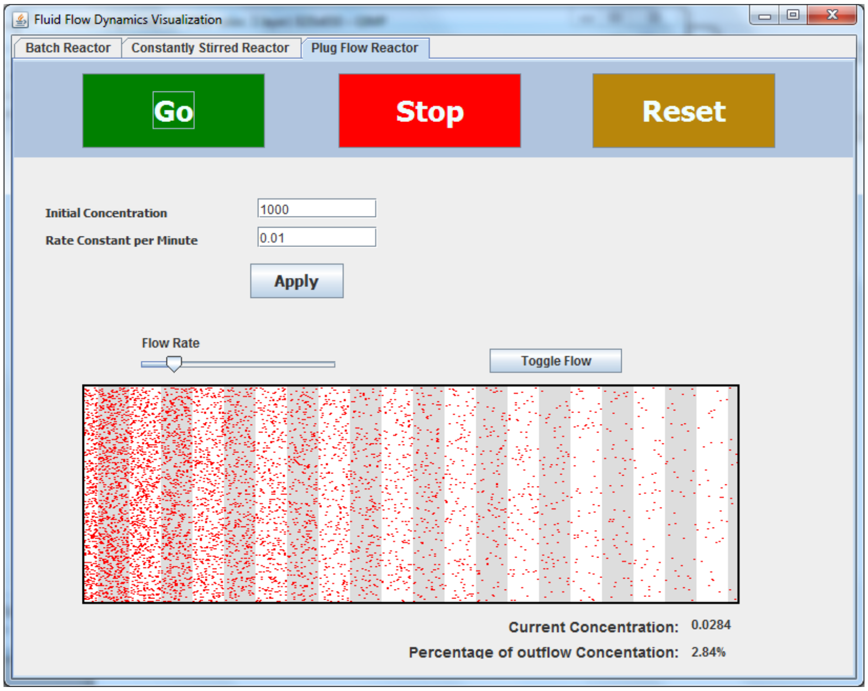


A constantly stirred reactor has a holding tank that constantly filters its contents with a constant in-flow and out-flow. Fluid Flow Dynamics Visualization allows the user to specify the initial concentration, reaction constant, and flow rate. See the Appendix for a description of the algorithms used in simulation.

The concentration per cycle is shown in the CSTR Data dialog. The CSTR Visualization dialog gives a pictographic representation of the change in particulate concentration in the out-flow. The change in particle concentration is shown visually by the density of dots in the simulation. The Current Concentration and the Percentage of Inflow Concentration, which is the current concentration divided by the initial concentration, are shown in the lower right of the window.

The initial concentration, reaction constant, and flow rate can be set by entering numerical values in their respective fields; "Initial Concentration", "Rate Constant per Minute", and "Inflow Rate", and then clicking the Apply button.

7 Plug Flow Reactor



A plug flow reactor operates by having a constant in-flow and out-flow through a filtration tube. Fluid Flow Dynamics Visualization allows the user to specify the initial concentration, reaction constant, and flow rate. See the Appendix for a description of the algorithms used in simulation.

The change in particulate concentration is shown with the in-flow on the left and out-flow on the right. The flow is shown by wight and gray bands. The change in particle concentration is shown visually by the density of dots in the simulation. The Current Concentration and the Percentage of Outflow Concentration are shown in the lower right of the window. The Current Concentration is the concentration in the out-flow. Percentage of Outflow Concentration is the current concentration divided by the initial concentration.

The initial concentration and reaction constant can be set by entering numerical values in their respective fields; "Initial Concentration" and "Rate Constant per Minute", and then clicking the Apply button. The flow rate can be changed dynamically by using the "Flow Rate" slider. Move the slider left to increase the flow rate and right to decrease. The "Toggle Flow" button will stop and start the in-flow, but the contents within the rector will continue to flow.

8 Appendix

8.1 Batch Reactor Dynamics

The dynamics of the batch reactor is described by the equation

$$C = C_0 e^{-kt},$$

where C_0 is the initial concentration, k is the reaction constant, t is time, and C is the current concentration. Time is automatically set initially to 0 and is incremented by 1 for each cycle in the simulation.

8.2 Constantly Stirred Reactor Dynamics

The constantly stirred reactor is simulated in discrete increments by taking a weighted average between the reactor contents and the in-flow contents

$$C' = C_{\text{tank}}(1 - P) + C_{\text{in}}P$$

and then subtracting the amount concentration removed by the reactor

$$C = C' - kC',$$

where C_{tank} is the concentration in the tank, P is the percent volume of the reactor solution being replaced, C_{in} is the in-flow concentration, k is the reaction constant, and C is the resulting concentration in the tank. Time is automatically set initially to 0 and is incremented by 1 for each cycle in the simulation.

8.3 Plug Flow Reactor Dynamics

The plug flow reactor is simulated by partitioning the filtration tube into a series of batch reactors. Each batch reactor controls its own state and visual output. The plug flow reactor changes the location of the batch reactors to simulate the change in concentration with distance traveled by the solution. When a batch reactor exits the plug flow reactor, the concentration of the batch reactor is recorded as the current concentration, and the batch reactor is destroyed. New batch reactors are created at the start of the plug flow reactor.