Memorandum

Date: 27 January 2010

To: Noel R. Urban

From:

Re: Distributions

Cc: Bo Zhang

In waste water treatment plants completely mixed batch reactors (CMBR), completely mixed flow reactors (CMFR), and plug flow reactors (PFR) are used to treat and filter the water. The PFRs are used as filters for settling according to Stokes Law. Our objectives is to determine from the concentration of red dye into a PFR, whether or not there is conservation of dye, interpretation of mathematical and graphical data to determine if the PFR follows ideal or non-ideal conditions, and finally the data is analyzed to see if the plume that is leaving the reactor has more of a normal or lognormal bell shape curve.

Final results show that team 5’s plug flow reactor did not follow those of show ideal conditions behavior. The average dye detention time was at 24.0 minutes, a little over half of the theoretical detention time of 41.7 minutes (calculated by the equation V/Q, where V is the volume of the tank and Q is the flow rate). This is due to changes in temperature, with warmer water towards the surface and cooler water towards the bottom, forcing flow from the top of the tank, to the bottom of the tank, until it reaches the end of the tank, forcing it towards the effluent at the top of the tank. This creates enough power to force some of the dye back into the tank, mixing it. The detention time is also lowered because of the outlet currents due to the 5 baffles slowing the current. There were 4.68 mL of dye collected (calculated by [the area under the concentration vs. time graph * average flow rate]). This is more than what was to be put into the tank according to the procedure (3 mL), but would make sense given that there was an accidental injection of the wrong dye, followed by an injection of the correct amount of the right concentration of dye.

When conducting the lab exercise our group followed the directions as noted in pages 9-10 in the EMMA hand out of Lab Exercise 2, Plug Flow Reactors. The dimensions of the tank (1.00mX.325mX.265m), the influent and effluent temperatures (10.15°C and 10.15°C respectively), and the average flow rate from 4 samples were recorded (average flow rate was 2.063L/min). The red dye was then inserted (along with our mistaken insertion, 3.00mL+). After every minute, a sample of water from the effluent was taken and the absorbance from the sample was recorded. This went on each minute until the absorbance went back down to 0.000. The concentration of each sample was found using the equation of the slope of the Absorbance
vs. Concentration curve, \( y = 1.6051x \). They were put into an excel spreadsheet (encl. table 1) then plotted onto a graph (encl. figure 1).

- The Area under the concentration vs. time graph curve used in the volume and \( t_{avg} \) calculation was calculated using the equation:
  \[
  \sum C_i \Delta t_i, \text{ where } C_i = (C_1 + C_2)/2 \text{ and } \Delta t = (t_2 - t_1).
  \]
  Using excel, the area under our curve was calculated to equal to 2.637 mL/L*min.

- Our average time used in finding the pdf for a normal distribution was calculated using the equation:
  \[
  \sum [t_i C_i \Delta t_i] / (1/Area), \text{ where } t_i = (t_1 + t_2) \text{ and } C_i \ & \Delta t \text{ are as above.}
  \]

- Our average residence time was calculated to be 26.8 minutes. The pdf equation used for the normal distribution curve (shown on Figure 1 as a solid line) was:
  \[
  C(t) = M/V^*(1/\text{SQRT}(2\pi\sigma^2))*\exp\left[-(t-t_{avg})^2/(2\sigma^2)\right].
  \]

The data points plotted on the enclosure of figure 1 show that our data is under the normal distribution curve, over the curve, then under again.

The tank that our group used had five baffles in it. While some other groups had less or none at all, this will allow for each group to have unique data based on what type of tank they had. The tank we had behaved the most like a plug flow reactor, having the smoothest curve. However, no matter how many baffles a group had, they all had detention times below theoretical detention times.

The reactor did not behave as an ideal plug flow reactor. The reason why was that the water entering the tank was colder than the water in the tank, creating a temperature gradient that mixed the influent and caused the plug not to mix top-to-bottom and stopped it from being a true plug flow.

The tracer was conservative, but it was mixed up as it moved through the tank not allowing it to properly exit the tank. When cleaning our group noticed there was some residual at the top of the water level, this may have been due to temperature gradients in the water forcing the influent to remain at the surface of the water or settle out in a dead zone.

References: Nice!


Comment [NRU1]: What data leads you to this conclusion?
Attached in e-mail Excel Raw Data Sheet: Lab 2 absorbance and concentration results. Give the file name.

Encl.

Figure
Figure 1: Concentration of Red Dye in PFR vs. Time. This graph represents data collected from a Plug Flow Reactor containing 5 baffles during EMMA class of spring 2010.
CE3502
Laboratory Memo Evaluation Sheet

I. Header 5/5
   1/1) Date 1/1) To 1/1) From/Initials/Signature 1/1) Subject 1/1) References

II. Purpose 9/10
   4/5) Why are we concerned with this topic (background info) 5/5) objective of lab

III. Procedure 2/2
   1/1) Reference lab handout 1/1) Changes made to lab

IV. Results 13/15
   Sig.figures 3/3 Graph 3/3 Area under curve 3/3 Tavg 3/3 Avg. Flow 1/3

V. Discussion of Results 18/20
   3/3 All topics covered; 5/5 Statistics tests employed correctly; 5/5 Statistics results interpreted correctly; 4/5 topic understanding; 1/2 readability;

VI. Conclusion 10/10
   4/4) State important findings 3/3) Report findings quantitatively 2/2) State significance of findings 1/1) Assumptions/Sources of Errors if important

VII. Tables, Figures, Attachments 9/10
   1/2) Label Attachments A, B, etc. 2/2) Number and Title Tables 2/2) Number and Title Figures 2/2) Units 2/2) Label Axis

VIII. Composition 16/20
   1/2) Spelling 1/2) Grammar 3/3) Paragraph organization 2/2) Sample calculation 2/3) Meaning behind writing 3/3) Not concise writing; 2/3 Sentence organization, structure 2/2 Memo organization into sections

IX. Overall Appearance, Organization 8/8
   2/2) Ease of finding data (including summary tables) 2/2) Neatness of tables/figures 2/2) Neatness of sample calcs 2/2) Neatness of memo format

Name of Student: ________________________________

Total Points for Report (100 Maximum): 90/100

Comments: Nice job!! You really did a good job of correcting the formatting issues noted in your first memo. You have all the mechanics of putting together a good memo down well, and you demonstrated that you understood the theory and calculations. If you can improve your writing style a little, your score will be even better. Your sentence structure and choice of words do not always convey your meaning well.