Experiment

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UNIVERSITY OF ALBERTA

Department of Chemical & Materials Engineering

CH E 572

Dynamic Modelling of a Distillation Column

Introduction

The distillation column used for this experiment is located in CME 108A.
You will need a USB memory stick to complete the experiment.

The ChE572 Consulting Group has been contracted to develop a dynamic model for a distillation column. The model may ultimately be used to design a process control scheme, but our first task is to capture the main dynamic characteristics of the column. Our company's standard approach to these assignments is to begin with some empirical process modelling.

Recall that distillation is the most common unit operations used to separate liquid mixtures. As you learned in your undergraduate studies, the distillation process takes advantage of volatility differences between the components in the mixture to effect a separation (*i.e.,* the more volatile components travel upward, while the less volatile components travel downward in the column).

Our objective for this experiment is to develop empirical dynamic models that approximate the transient behaviour of a binary distillation column, to the desired degree of accuracy. In this experiment, dynamic models will be developed relating the behaviour of the output variables (overhead and bottoms compositions) to the input variables (reboiler steam rate and reflux rate).

General Instructions

The purpose of this experiment is to determine the transient operating characteristics of a five (sieve) plate distillation column used for separating methanol and isopropanol. This distillation column takes a considerable amount of time reach steady-state. As a result, the experiment will take at least three hours to complete. Finally, the distillation column has an extensive set of instrumentation for measuring and controlling the process variables; however, there are some variables of interest that cannot be measured using the available instrumentation.

Given that the modelling objective is an accurate prediction of overhead and bottoms product composition for changes in reboiler steam rate and reflux rate, this experiment will require completion of a number of activities and the solution of a number of problems, including:

1) how will overhead and bottoms compositions be determined at each sampling instants,

2) what actuators will be manipulated during the experiment,

3) what input signal will be used (shape and duration),

4) what data must you collect to develop your models (remember to include measurement accuracy in your considerations).,

5) what sampling rate should you use for both automatic (computer-based) and manual (recorded by hand) data collection?

Each of these items needs to be addressed before you come to the lab. It would be helpful for you to visit the distillation column well before the lab.

Safety

The distillation column uses a mixture of methanol and isopropanol. Both alcohols are very volatile and flammable. Also, parts of the equipment can become quite hot. It is essential that you are aware of all safety precautions while in the laboratory. Some of the laboratory rules are:

i) No open flame is allowed within the laboratory.
ii) Two fire extinguishers are located near the distillation column. Become familiar with their location and operation before starting the experiment.
iii) There is a fire alarm located next to the east elevators. In the event of a fire, ring the alarm and follow the posted instructions.
iv) Some of the equipment can become very hot. Please be very careful.
v) This experiment requires that you wear **long-sleeved shirts, long pants and safety glasses**. You will not be allowed to proceed with the experiment until you meet these requirements.
vi) **Do not drink the alcohols**. Ingestion can cause blindness or death.

Instrumentation

Temperature Measured	Thermocouple Name
Tray #1 (Top)	Tray #1
Tray #2	Tray #2
Tray #3	Tray #3
Tray #4	Tray #4
Tray #5	Tray#5
Cooling Water - Inlet	Cooling In
Cooling Water - Outlet	Cooling Out
Top Product	Top Product Out
Steam to Reboiler	Steam In
Reboiler Condensate	Steam Condensate
Reboiler Liquid / Bottoms Product	Reboiler Liquid
Feed	Feed
Reflux to Column	Reflux In

Column Data

Column Diameter	0.153 m
Hole Diameter	4.76 mm
Tray Spacing	0.318 m

Report Requirements

One report per group is required. Each group must contain at least three and not more than five group members. Remember this report is worth approximately 20% of the total marks available in this course and represents a very realistic modelling scenario, so it is well worth expending a good effort. Your concise report should conform to the style expected of all professional reports and contain the following analyses / information:

a) All assumptions you have made.
b) A method to predict overhead and bottoms product compositions from available measurements (including an analysis of its accuracy).
c) The empirical dynamic models and their estimated parameter values (including the accuracy of the parameter estimates and the model predictions) in both transfer function and state space form.
d) Suggestions for improving your empirical models.

Suggested References

Bequette, B. Wayne, *Process Dynamics: Modeling, Analysis and Simulation,* Prentice-Hall, 1998.

Box, G.E.P, Jenkins, G.M., *Time Series Analysis: Forecasting and Control*, Holden-Day, 1976.

Draper, N., Smith, H., *Applied Regression Analysis*, Wiley, 1966.

Treybal, R.E., *Mass-Transfer Operations*, 3rd ed., McGraw-Hill, New York, 1980.

Wankat, P.C., *Equilibrium Staged Separations*, Prentice-Hall, New York, 1988.