PROCESS DYNAMICS – CPN321

SEMESTER TEST 1

Chemical Engineering
Engineering and the Built Environment

Examiner: Carl Sandrock

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Instructions – Read carefully

• Answer all the questions. • This is a closed book test. All the information you may use is contained in the paper and the attached formula sheet. • Make sure that you motivate all your answers and write legibly.

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1 Mixing approximation

An isothermal, irreversible reaction

$$\mathrm{A} \xrightarrow{k} 2\mathrm{B}$$

takes place in the liquid phase in a constant-volume reactor. The mixing is *not* perfect. Observation of flow patterns indicate that a two-tank system with back mixing, as shown in the sketch below, should approximate the imperfect mixing.

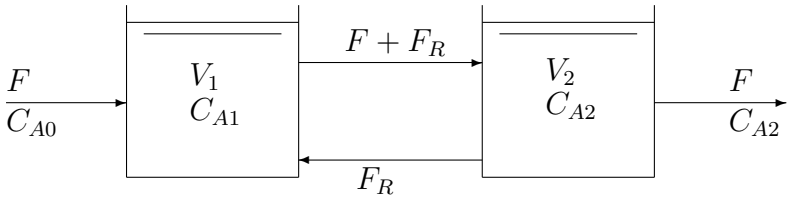

Figure 1: Back mixing system to approximate imperfect mixing

1. Assuming F and F_R are constant, develop a dynamic model describing the concentrations of A and B in the two tanks. (10)
2. Classify the variables in your model as inputs, outputs or parameters (5)
3. Rewrite these equations as a linear system of ODEs in terms of the concentrations of A and B in the two tanks. Use matrix notation. (15)

(30)

2 Multicomponent decanter

A decanter can be used to separate immiscible liquids. The liquids separate out and float on top of one another in distinct phases with the most dense phase at the bottom and the least dense phase on top.

A company is attempting to develop a new decanter which will separate N phases. You have been assigned to develop a model that will predict the levels of the different phases given an online measurement of the flowrates of each phase in the feed line. The decanter will be formed from a vertical pipe section with a circular cross-section. This model will be used to locate the interficial points so that the pure liquid can be removed. The liquid levels ($l_i,\ 1 \leq i \leq N$) are measured from the bottom of the decanter to the point between two components or the top of the whole liquid column.

You may assume that the densities of the liquids are constant and that each liquid is removed from the decanter at a rate proportional to the pressure at the bottom of that liquid layer.

Remember to keep your analysis general for N components.

1. Draw a diagram showing your choice of variables. [5]
2. Write down the model equations which will enable you to predict the liquid levels using index notation. [15]
3. Verify that simulation problem is correctly specified. [10]

[30]

3 Autonomous vehicles

Google is developing completely autonomous vehicles which are able to navigate in urban environments without human intervention. Plainly put, these cars "drive themselves".

1. Identify the control objectives of this system [5]
2. What measurements could be used to achieve these control objectives? [5]
3. For these objectives, identify the manipulated and controlled variables. [5]
4. Draw a diagram of the system indicating the feedback control loops. Include a key showing what the symbols you have used mean. [5]
5. What disturbances do you feel are likely? [5]
6. Identify which of these disturbances could be used for feed-forward control and indicate them on your diagram. [5]

[30]

Full Marks [90]

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www.latex-project.org