CHAPTER V

DISCUSSION OF THE RESULTS

In this chapter, the simulation results running by the present program and compared those results with the literature's have been discussed. The results can be separated to 3 categories. First, it can be discussed the examples of application to explain how to accept the present program. Second, the application to an oil refinery can be discussed what is the different among a full-order model, a five-compartmental model, and a four-compartmental model. Finally, the dynamic responses in the intermediate stages to study the behaviour calculating by compartmental concept against a full-order model has been discussed.

5.1 Examples of application

5.1.1 Example 1

In example 1, the given results from Table 4.2 are used as an initial condition to run a dynamic distillation with the present program. Because these initial conditions are the results from steady state calculation and there are no change in feed condition, therefore, the dynamic calculation should be steady in various times. From the results, Figures 5.1 and 5.2 show the composition responses of all components in reboiler and reflux drum in various times. It is seen from these figures that the dynamic behaviour of the column is also steady even in top and bottom stages and have some deviation from the steady state program, i.e., 3% and 5% respectively.

This is consistent with the basic theory that the behaviour of distillation will be steady at a point of time. These can be showed that the results from the dynamic distillation using the present program agree exactly with the results given by steady state calculation.

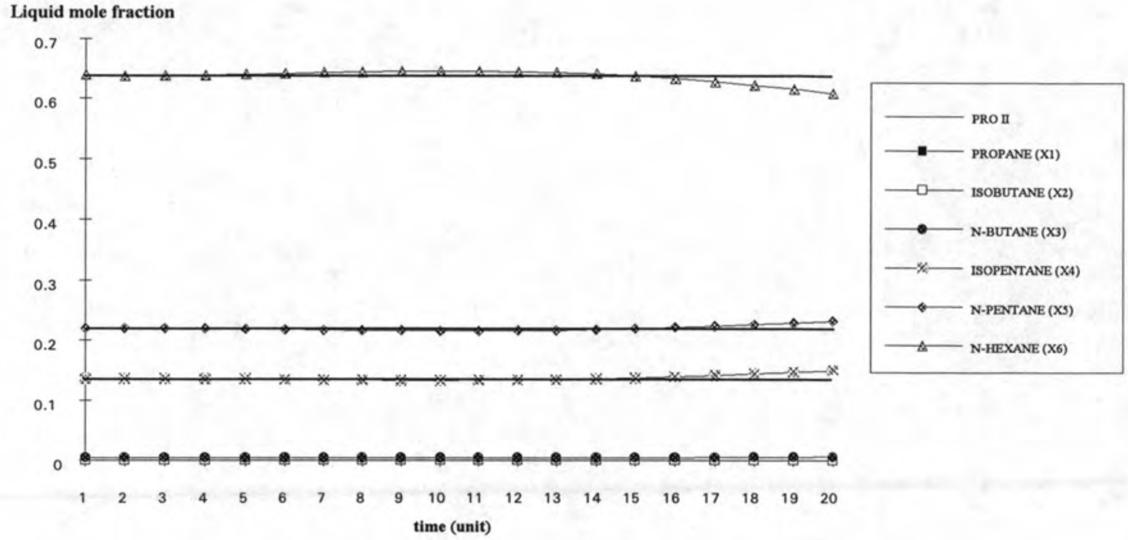

Figure 5.1 Reboiler compositions in various times.

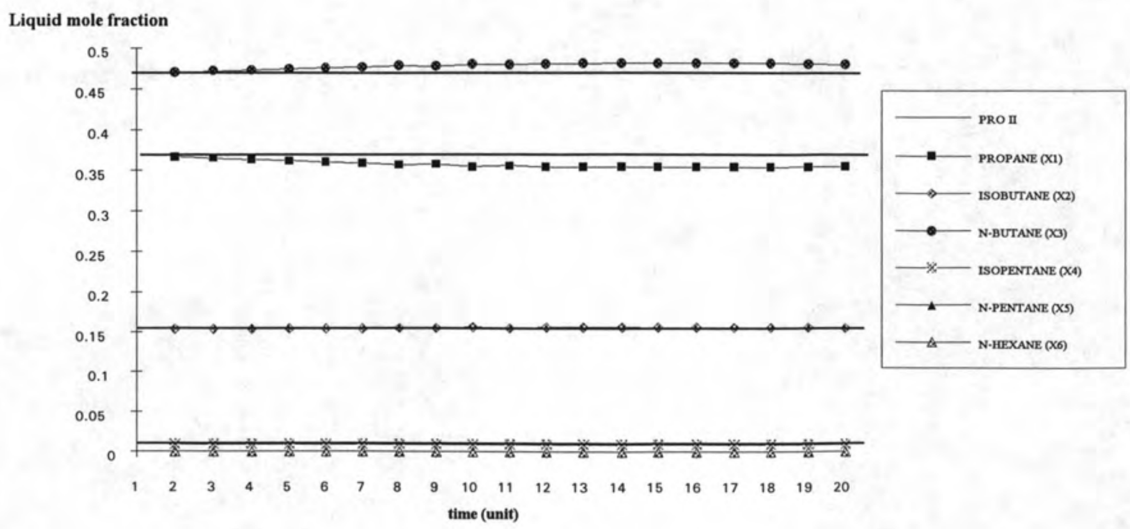

Figure 5.2 Distillate compositions in various times.

5.1.2 Example 2

In example 2, the given results from Table 4.2 are also used as an initial condition to run a dynamic compartmental distillation with the present program. This example shows the robustness of the compartmental technique that it can be predicted the full-order model steady state. Figures 5.3 and 5.4 show reboiler and distillate composition responses of all components in various times. From these figures, it is seen that all compositions in both of reboiler and reflux drum are steady in various times and give a good representation of the dynamics and yield exact steady state agreement, i.e., 2% and 5% deviation from steady state program for top and bottom respectively. However, the representations of the dynamics in the intermediate stages also consider for acceptation of the program. Figures 5.5 through 5.9 show the composition responses of the intermediate stages in various times. It is seen from these figures that the dynamic behaviour of the intermediate stages is also closely steady although some components, i.e., n-Hexane in compartment 1 and 2, and n-Butane in compartment 4 and 5.

Again, the results discussed above show the acceptation of the compartmental concept that it can be predicted the dynamic behaviour of distillation column with desirable accuracy.

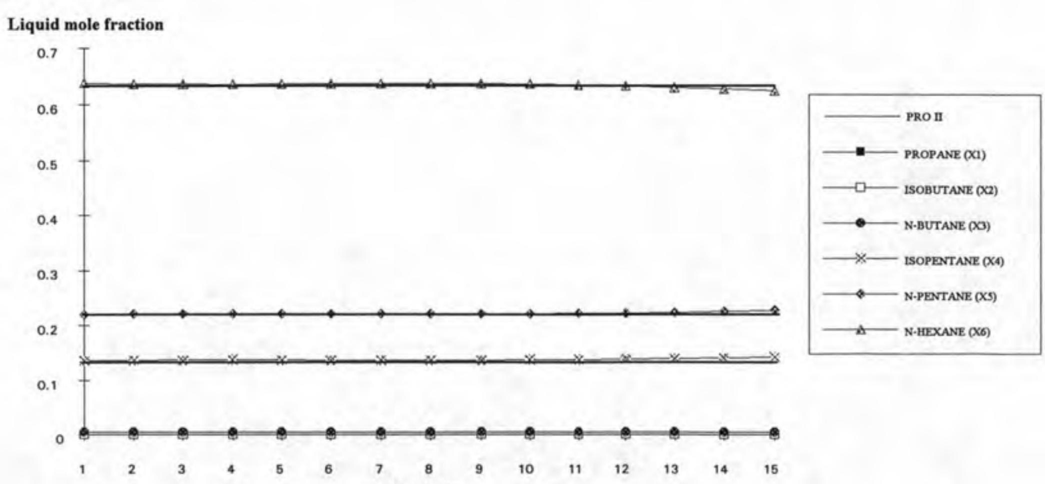

Figure 5.3 Reboiler composition using compartmental technique.

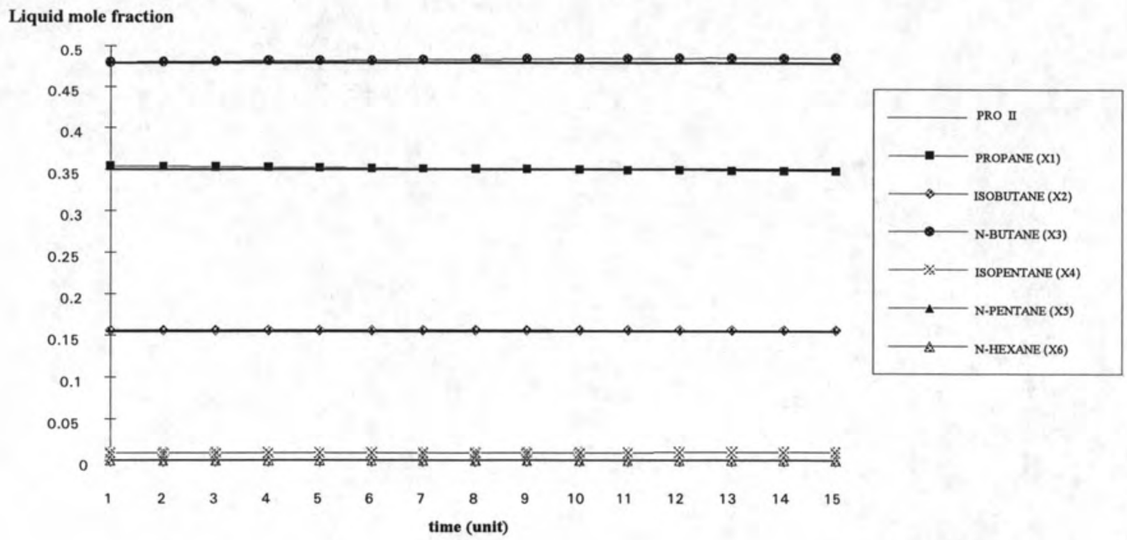

Figure 5.4 Distillate compositions using compartmental technique.

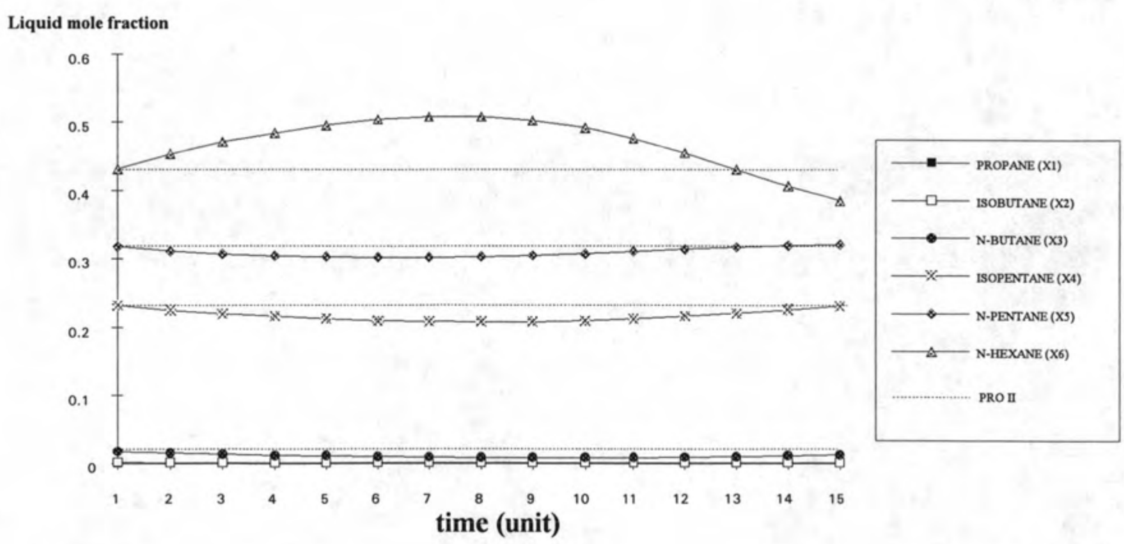

Figure 5.5 Composition in compartment 1 for 100% feed.

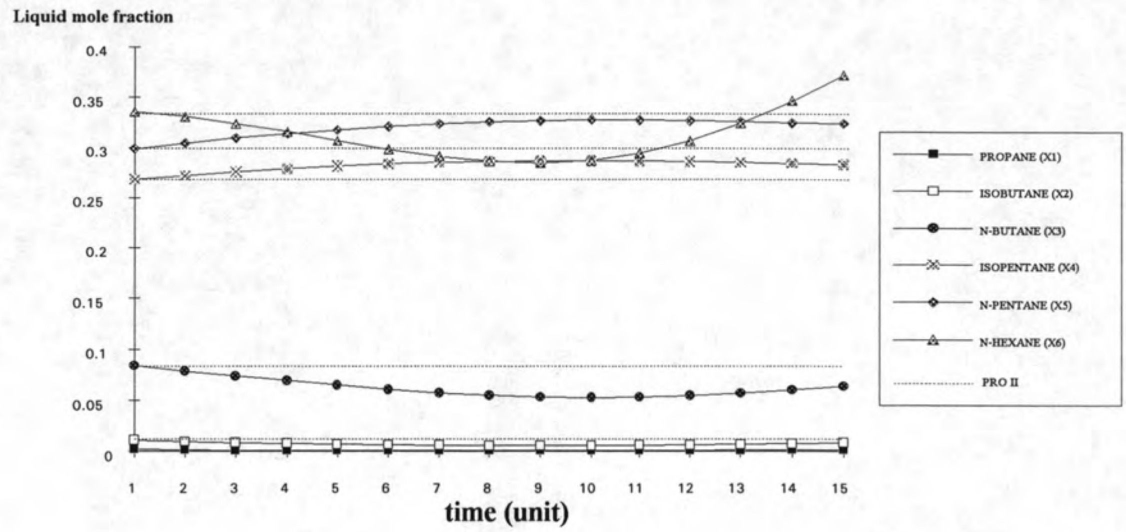

Figure 5.6 Composition in compartment 2 for 100% feed.

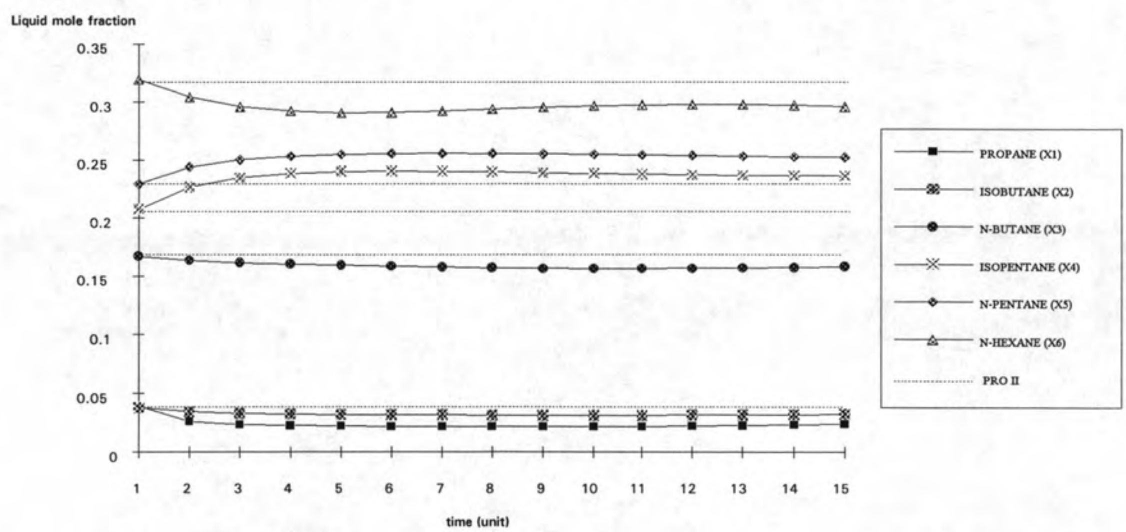

Figure 5.7 Composition in compartment 3 for 100% feed.

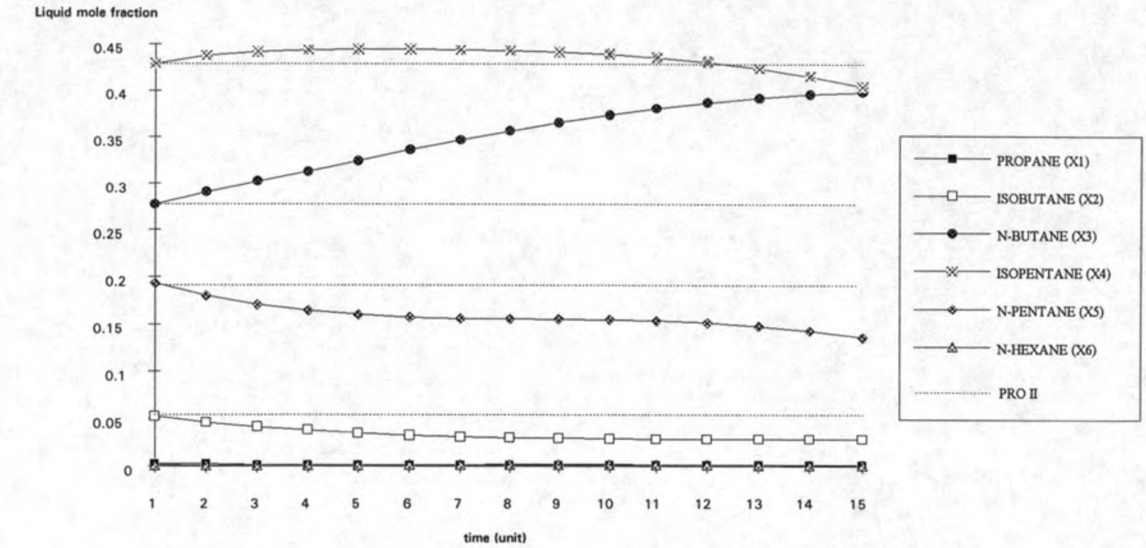

Figure 5.8 Composition in compartment 4 for 100% feed.

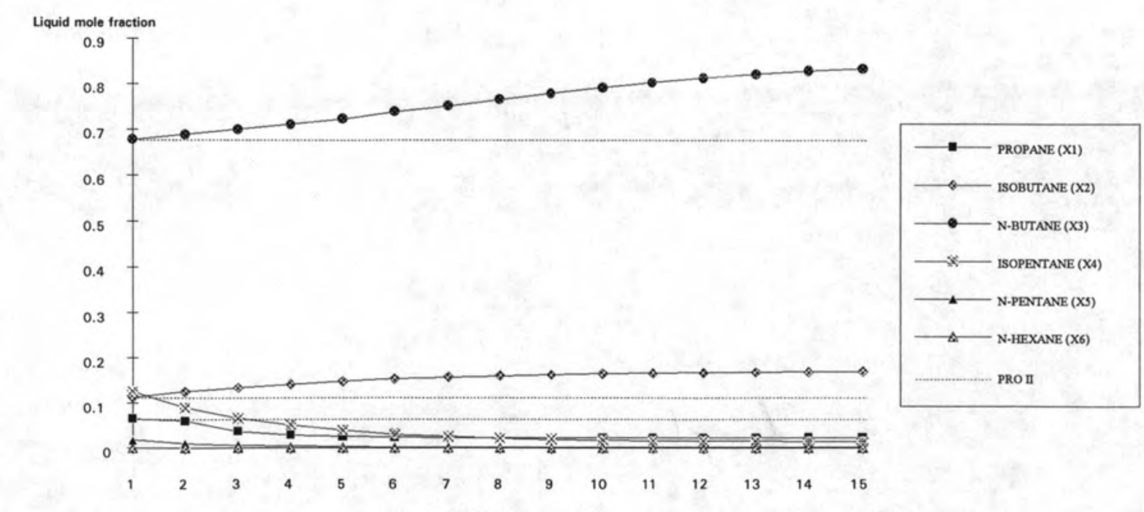

Figure 5.9 Composition in compartment 5 for 100% feed.

5.2 Application to an oil refinery

5.2.1 Application to +15% step changes in feed flow rate

Figure 5.10 shows the responses of the desirable distillate composition, n-Butane, plotting in various times. It is seen from this figure that when a +15% step change in feed flow rate is applied, the responses of desirable composition, n-Butane, would be increased and stepped up to a new steady state. Consequently, it is found that the dynamic behaviours that calculated by compartmental models, four- and five-compartment, have exactly representation to a full-order model at initial and final state. Anyway, a comparison with the desirable product, n-Butane, calculating by PRO II at new steady state, dotted line in Figure 5.10, also closely to the compartmental models and the full-order model. These results agree with the conclusion of Benallou et al (1986) that the compartmental model response shows a reasonably close representation of dynamics and, as expected, exact initial and final steady state agreement because these response characteristics are attributed to the fact that the compartmental model uses steady state relationships in its development. For comparison between a different compartmental model, it is found that the it has a slight effect on response accuracy between four- and five-compartmental model.

Figure 5.11 shows the responses of n-Butane in the reboiler plotting in various times. It is seen from this figure that when a +15% step change in feed flow rate is applied, the response of n-Butane would be decreased and stepped down to a new steady state. The dynamic behaviours in reboiler calculating from compartmental models also have exactly representation to a full-order model at initial state, however, its behaviours still unsteady at the final state. These also note that it needs more times to operate the column into new steady state even as steady in the top of column.

Once again, the obtained data showed that the compartmental technique can be predicted the dynamic behaviour of distillation column against full-order model.

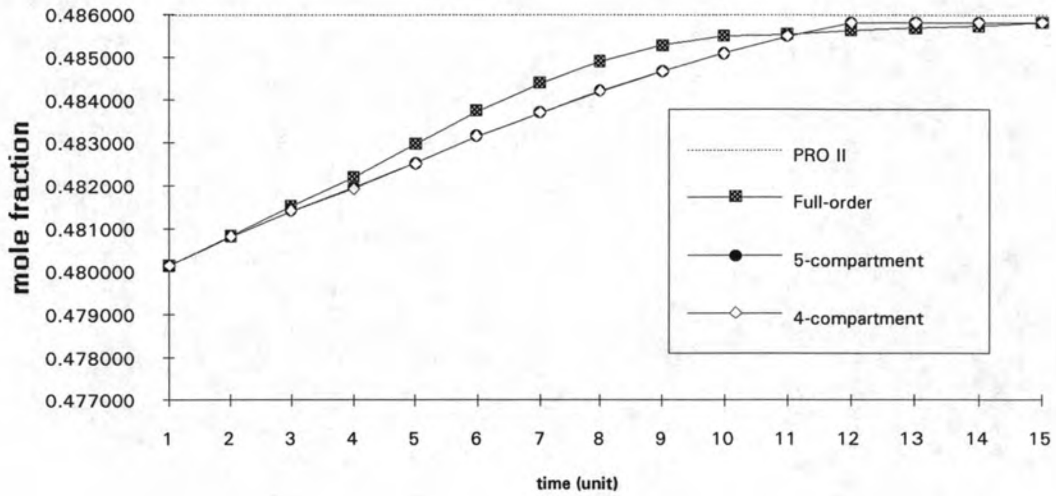

Figure 5.10 Distillate composition of n-Butane response to a +15% step change in feed flow rate.

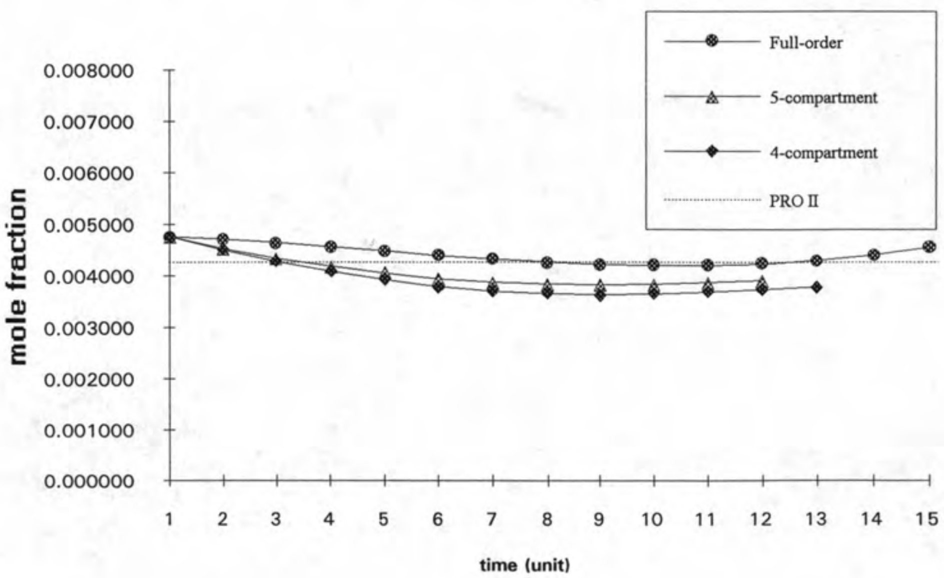

Figure 5.11 Bottom composition of n-Butane response to a +15% step change in feed flow rate.

5.2.2 Application to -15% step changes in feed flow rate

Again, this application is used to show the robustness of the present program. Figure 5.12 shows the dynamic response of the distillate composition, n-Butane, when applied to a -15% step changes in feed flow rate. It is seen from this figure that the response behaviour would be decreased and stepped down to a new steady state. The dynamic responses of the top stage show that both compartmental models have exactly representation to a full-order model at initial state and have closely representation to the steady state calculation, PRO II, in final state. These results concede with the conclusion of Benallou et al (1986) and the previous application that the compartmental model response shows a reasonably close representation of dynamics and exact initial and final steady state agreement.

Figure 5.13 shows the responses of n-Butane in the reboiler when applied with a -15% step changes in feed flow rate. It is seen from this figure that the response of n-Butane would be increased and step up to a new steady state. The dynamic behaviours in reboiler calculating from compartmental models and a full-order model have closely representation to the behaviour calculating from steady state program, dotted line in Figure 5.13.

Once again, the obtained data showed that the compartmental technique can be predicted the dynamic behaviour of distillation column against full-order model.

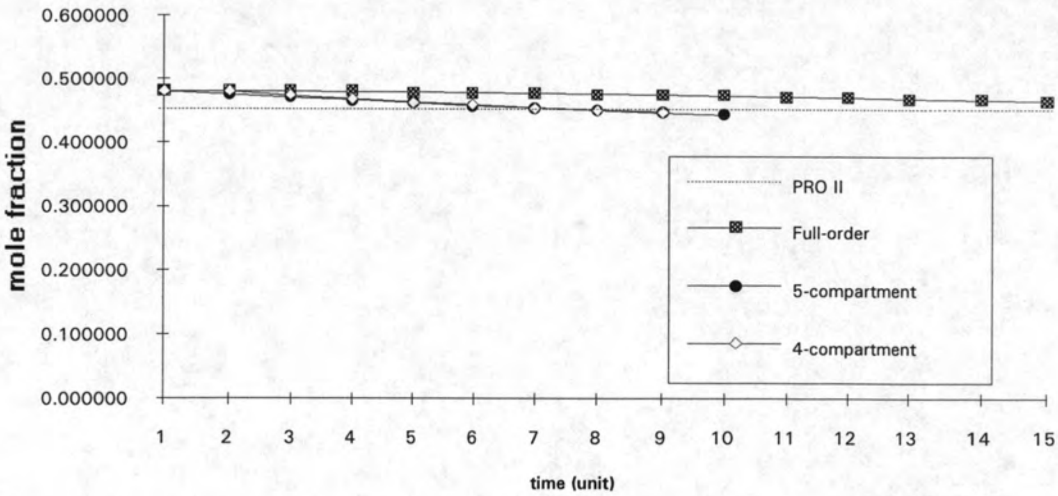

Figure 5.12 Distillate composition of n-Butane response to a -15% step change in feed flow rate.

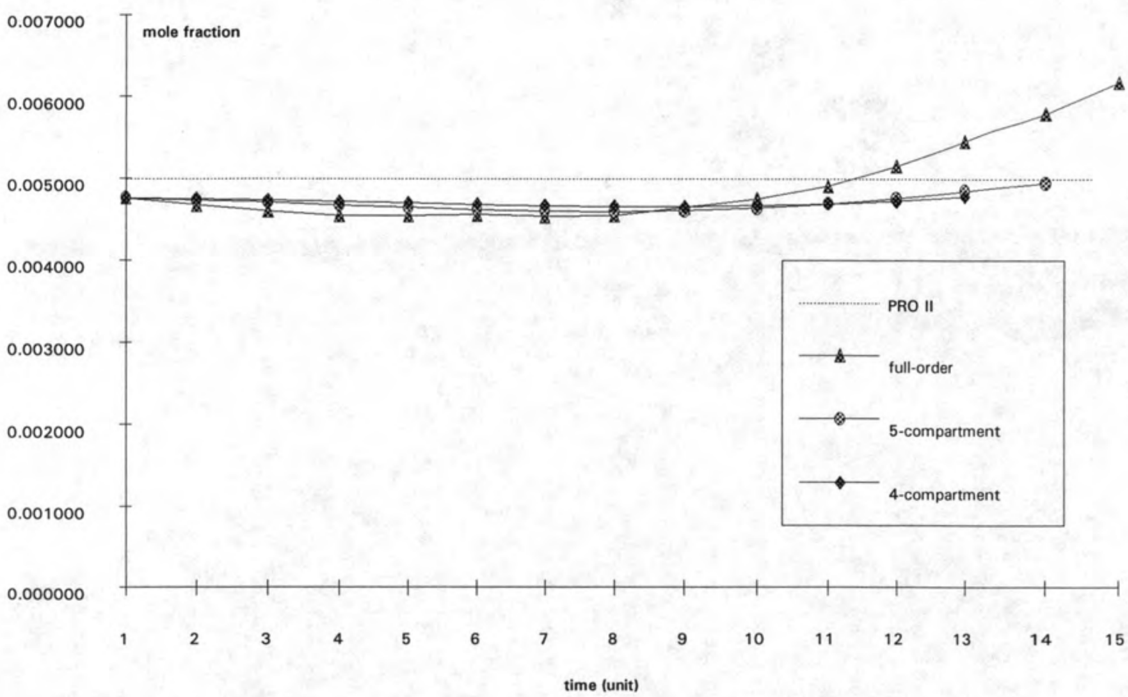

Figure 5.13 Bottom composition of n-Butane response to a -15% step change in feed flow rate.

5.2.3 Comparison of the intermediate stages

Figure 5.14 shows the behaviour of n-Butane in the intermediate stages (stage 2, 6, 9, and 22) between a full-order model and a four-compartmental model. A four-compartmental model is selected to compare the intermediate responses with a full-order model because the four-compartmental model was constructed by selecting the sensitive tray in rectifying section, tray 22nd of 4th compartment, as the upper portion of that compartment (Horton, 1990) while the sensitive tray in stripping section was taken midway from first and last stages in compartment (Benallou et al, 1986). It is seen from this figure that the sensitive tray, stage 22nd, in rectifying section and the sensitive tray, stage 2nd, in stripping section have closely representation to a full-order model. These results show that it has an only slight effect on response accuracy whether selecting the sensitive tray by guideline of Horton or Benallou et al. However, Horton has reported in 1990 that the sensitive tray selection has a significant effect on computational time but this point did not investigate in the research.

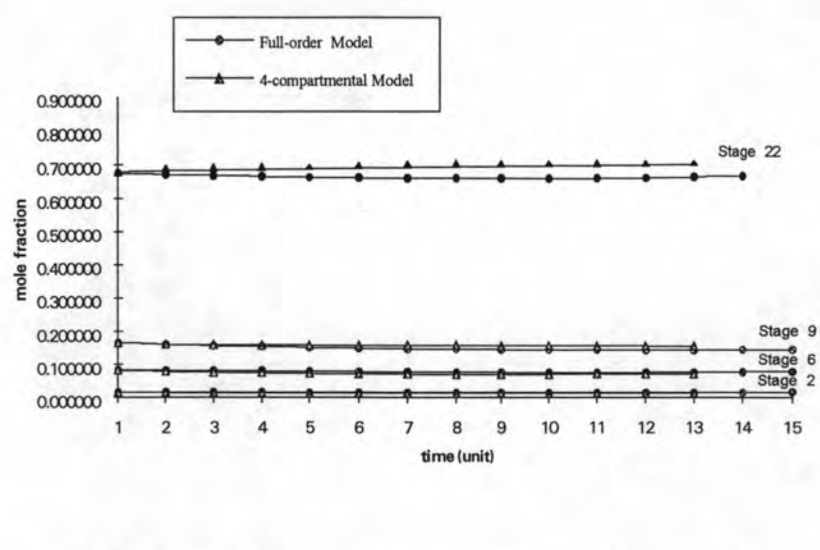

Figure 5.14 Composition of n-Butane responses of stage 2, 6, 9, and 22 to +15% step change in feed flow rate.