Loop-Pro® Project Work
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Outline of the Loop-Pro® Project Work:

DISTILLATION COLUMN

1) recognize on the process layout and list disturbances, set point, controller output and manipulated variables. How many are there?

2) simulate the "open loop" dynamic response as a result of a **step** variation of one of the disturbances

3) simulate the "open loop" dynamic response as a result of a **step** variation of one of the *controller outputs*

4) simulate the "open loop" dynamic response as a function of one of the disturbances, following a "limited ramp" variation

5) simulate the "open loop" dynamic response as a function of one of the *controller outputs*, following a "limited ramp" variation

6) discuss the "open loop" responses and propose a general comparison

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1. recognize on the process layout and list disturbances, set point, controller output and manipulated variables. How many are there?

- First, I open the program and choose the single-loop process from the menu.
- The selection of single-loop process shows the layout of the distillation column which lists the manipulated variables, the disturbance, control output and the set point.
- Disturbance has only one option:

  Feed flow

- Controller outputs of the reboiler and the condenser representing the flow rate of steam inlet at the bottom of column and the flow of liquid at the column head.

  Summary, the controller output are:

  a. CO (valve reboiler)
  b. CO (valvola condenser)

- It is possible to set automatically the set points of two controllers.

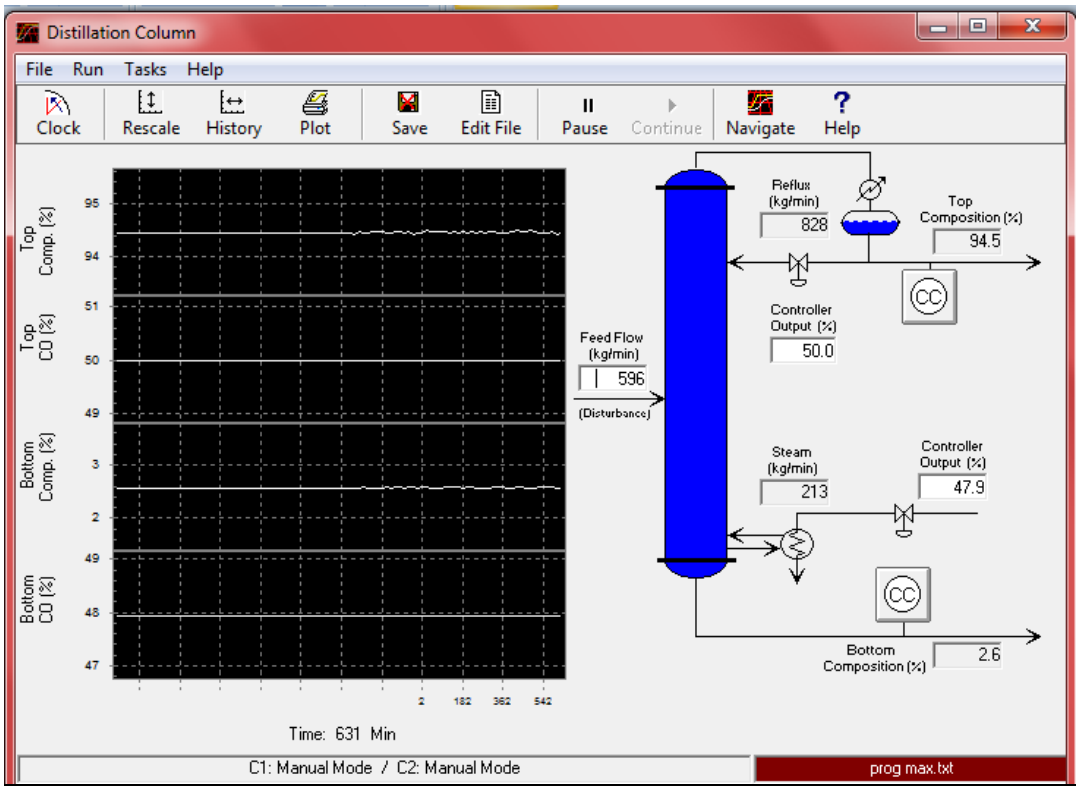
  Summary, the set points are:

  A. CO (valve reboiler)
  B. CO (valve condenser)

- The manipulated variabls are:

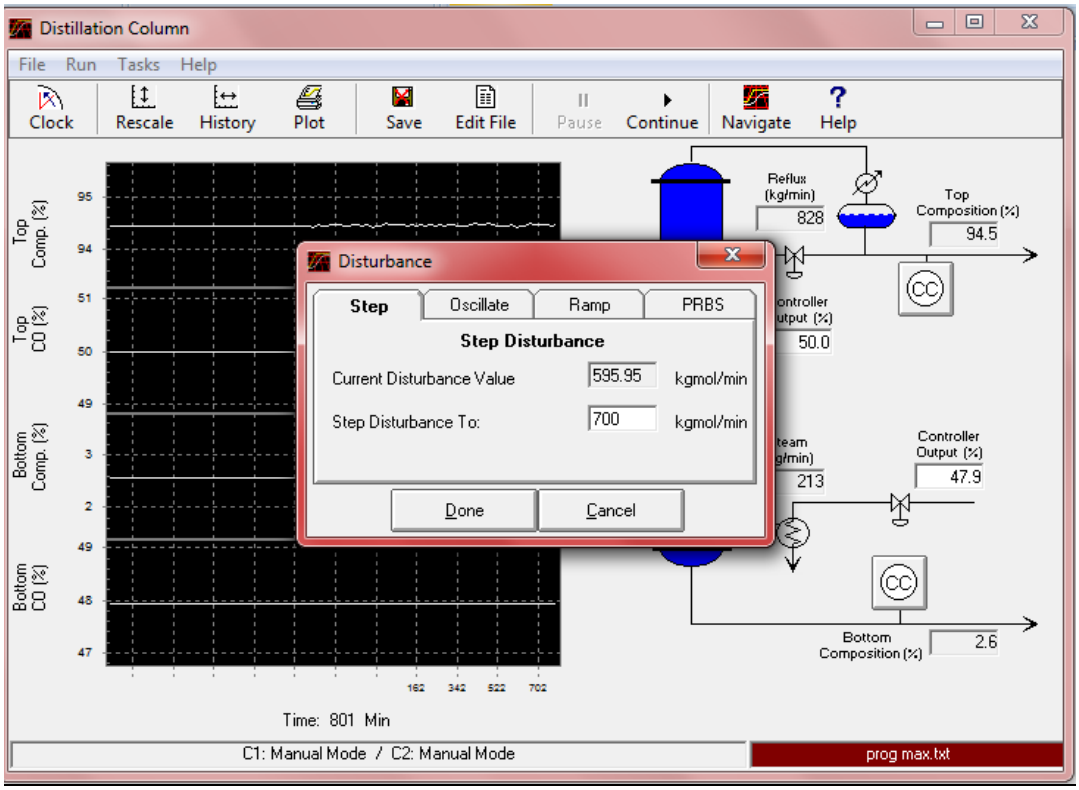
  the input current (disturbance) and the controller output of the reboiler and condenser:

  A. CO (reboiler)
  B. CO (condenser)

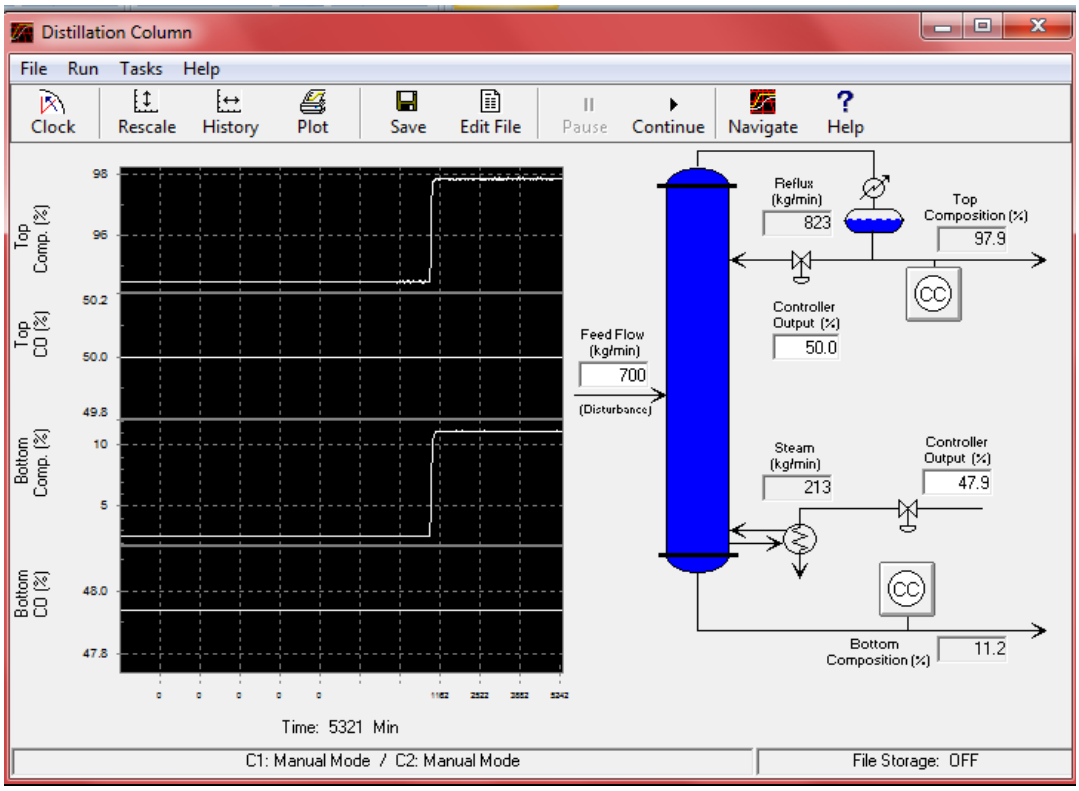


2. simulate the "open loop" dynamic response as a result of a step variation of one of the disturbances

- In order to simulate the system “open loop response”, i will manipulate the feed flow variable.
- On the interface this can be accomplished by using the default options of the program.
- By selecting the option "change process disturbance" in the menu “tasks”

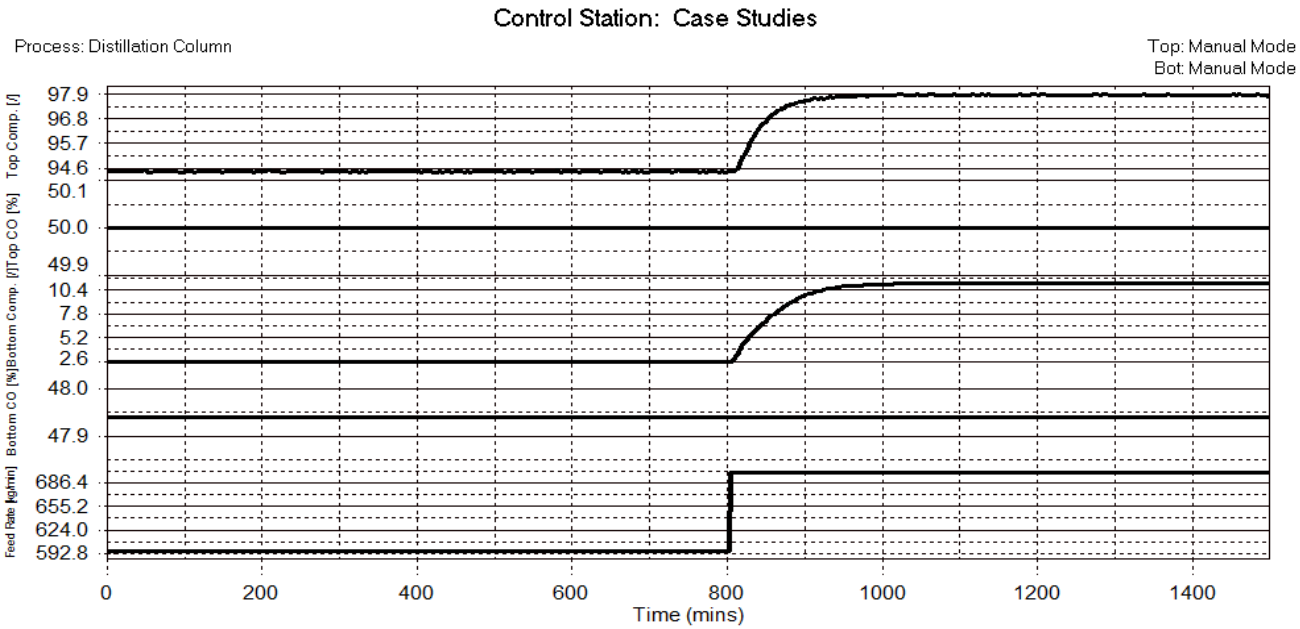


I choose to perturb the system changing the value of the disturbance from 595.95 kg/min to 700 kg/min (arbitrarily chosen).



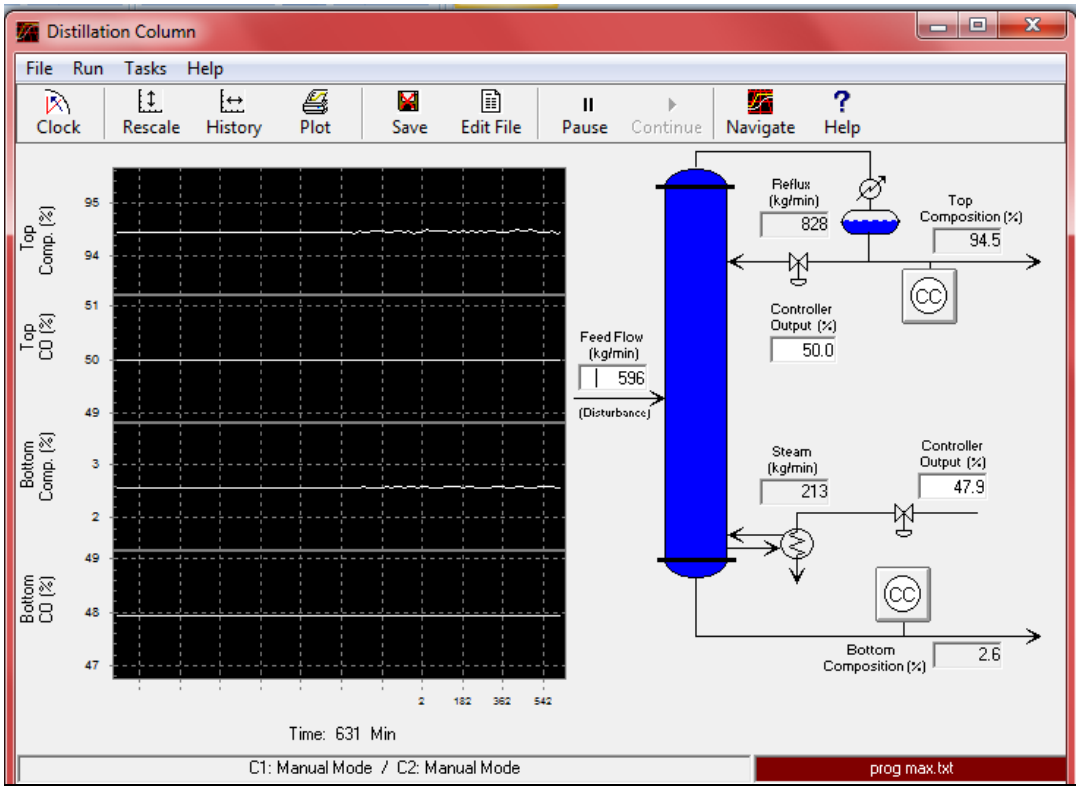
Once the variation of the disturbance then analyse in detail variables considered in a plot.

In the following graph it can be observed that the disturbance has a step variation. The two CO (condenser and reboiler) will lead to a new equilibrium value bringing the system to a steady state.

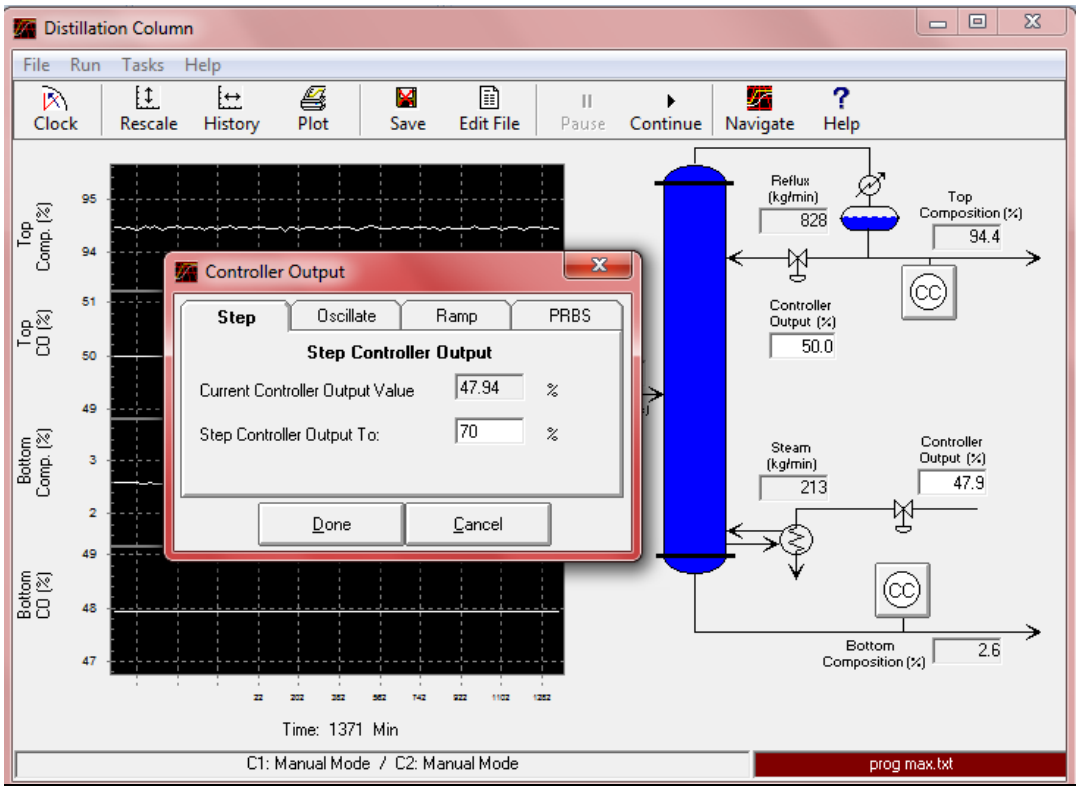


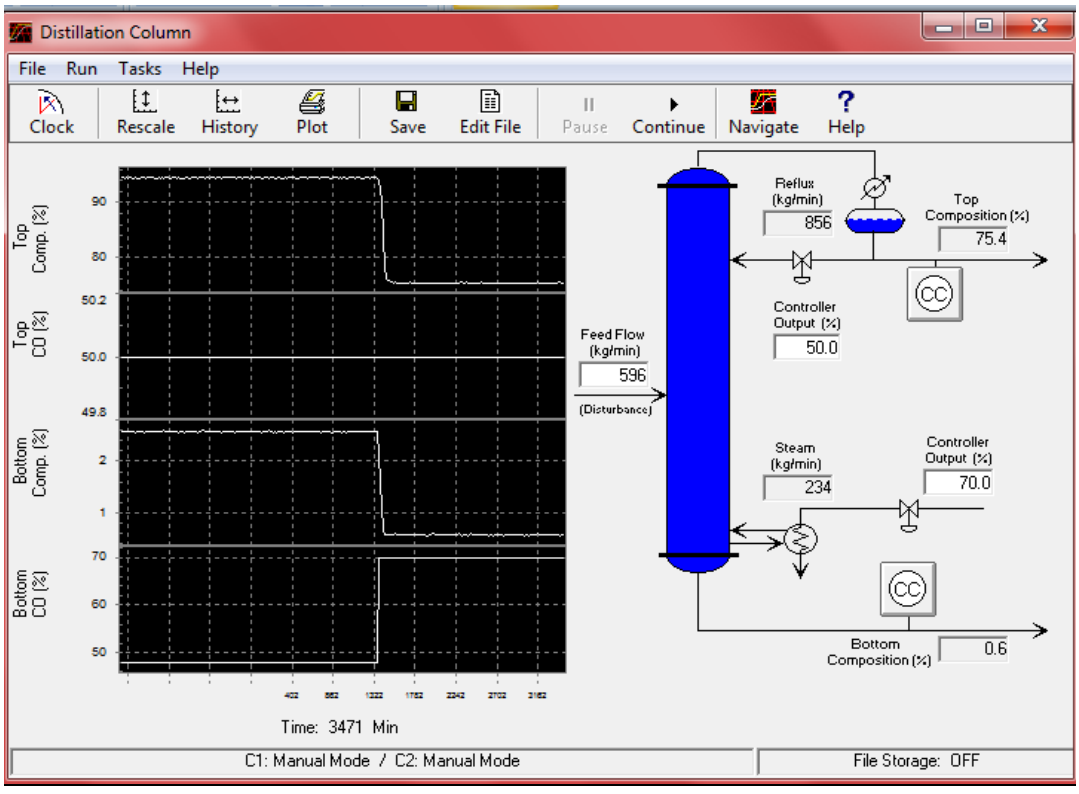
3. simulate the "open loop" dynamic response as a result of a step variation of one of the *controller outputs*

- In order to simulate the simulate the “open loop response”, i will manipulate one of the CO (riboiler) variable.
- On the interface this can be accomplished by using the default options of the program.
- By selecting the option “bottom: change control output”.

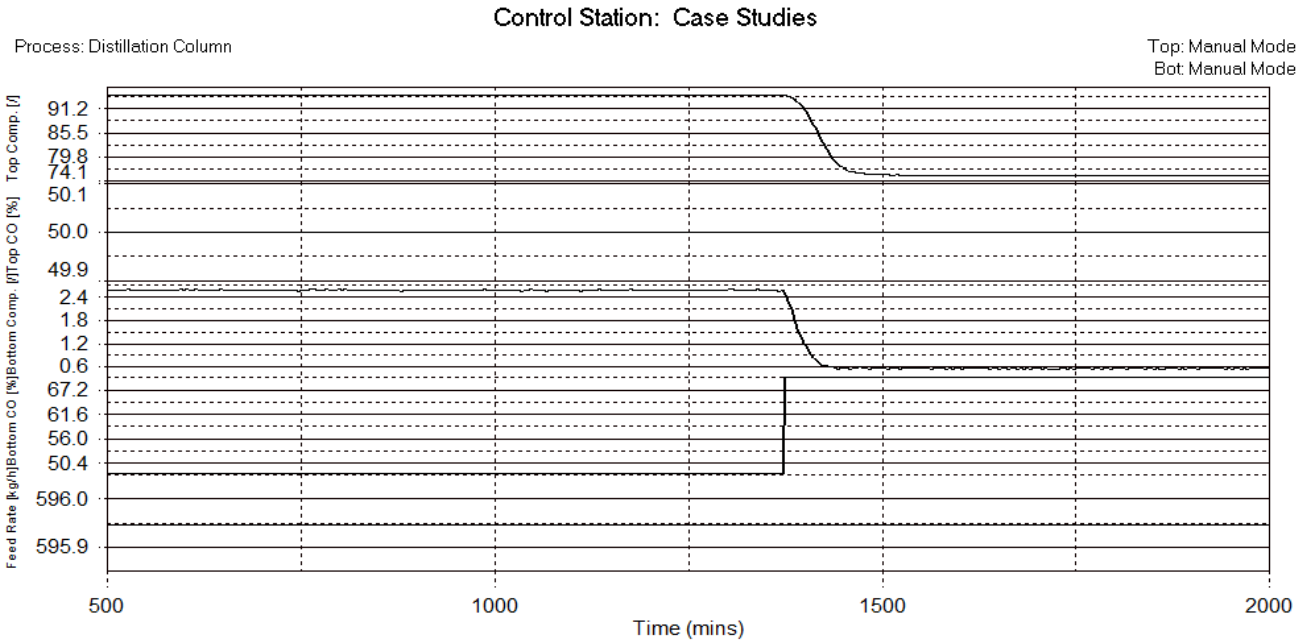


I choose to perturb the system changing the control output to the final value from 47.94% to 70% (arbitrarily chosen).



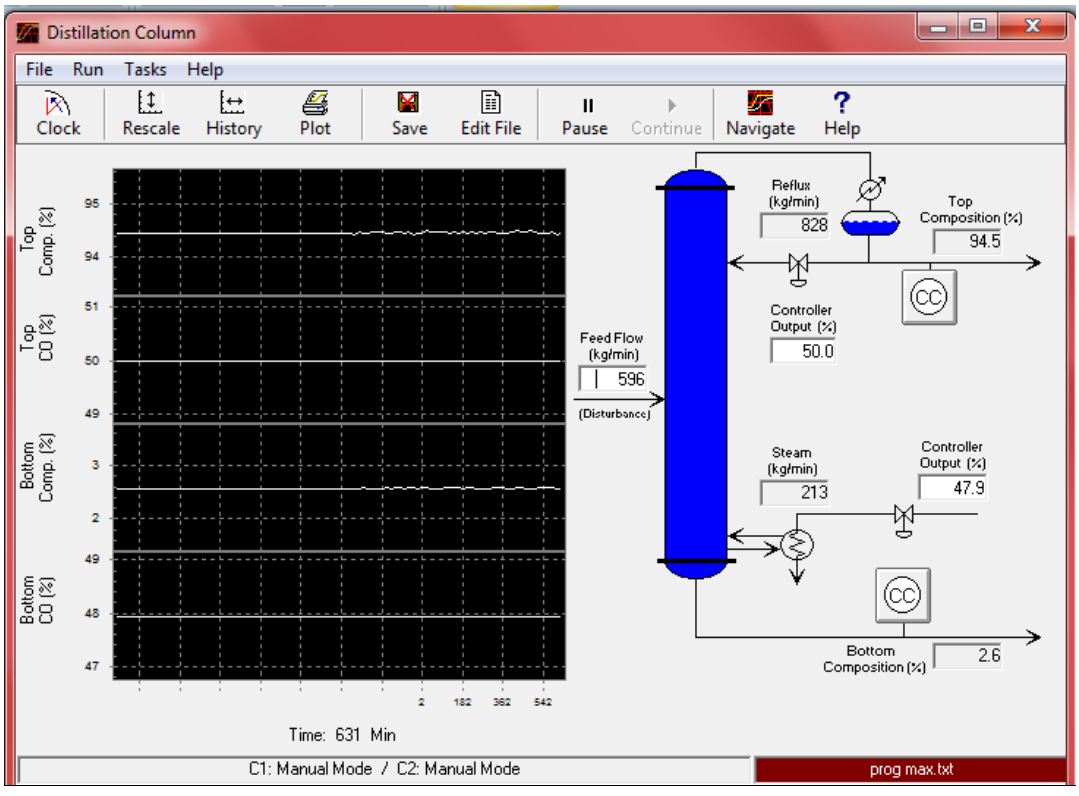


In the following graph, all the variables are represented as a function of time. The behaviour of the variables changed, moving for a new steady state after the disturbance.

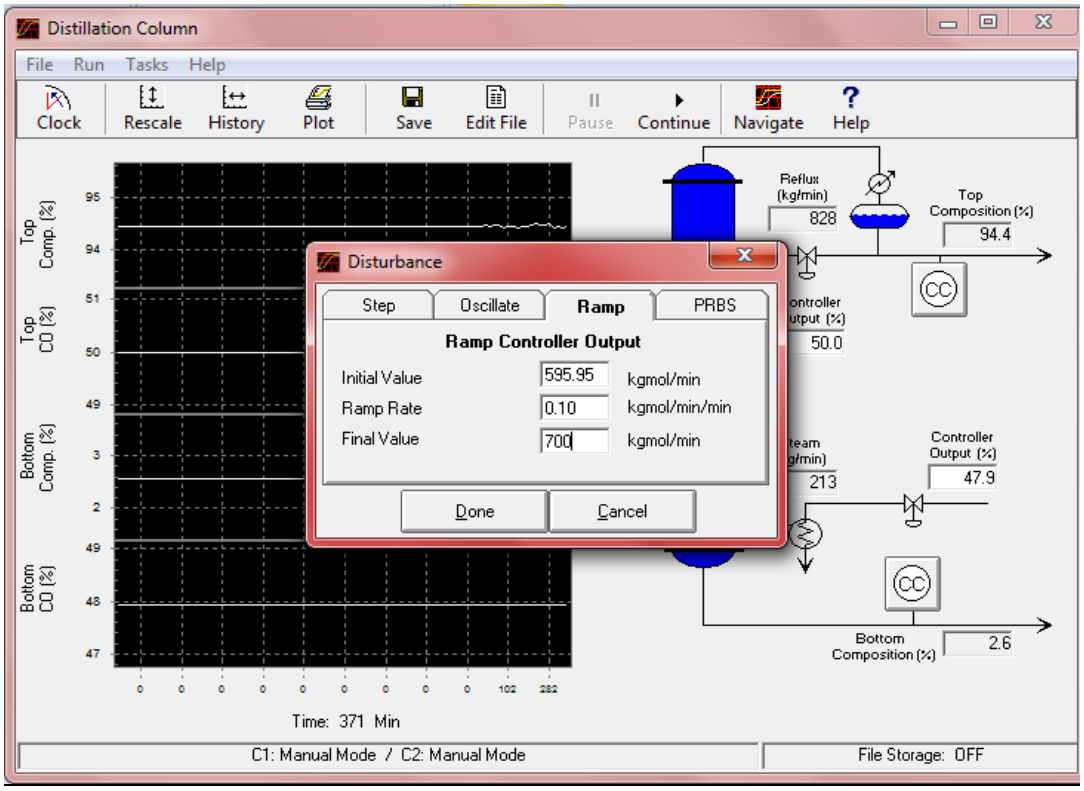


4. simulate the "open loop" dynamic response as a function of one of the disturbances, following a "limited ramp" variation

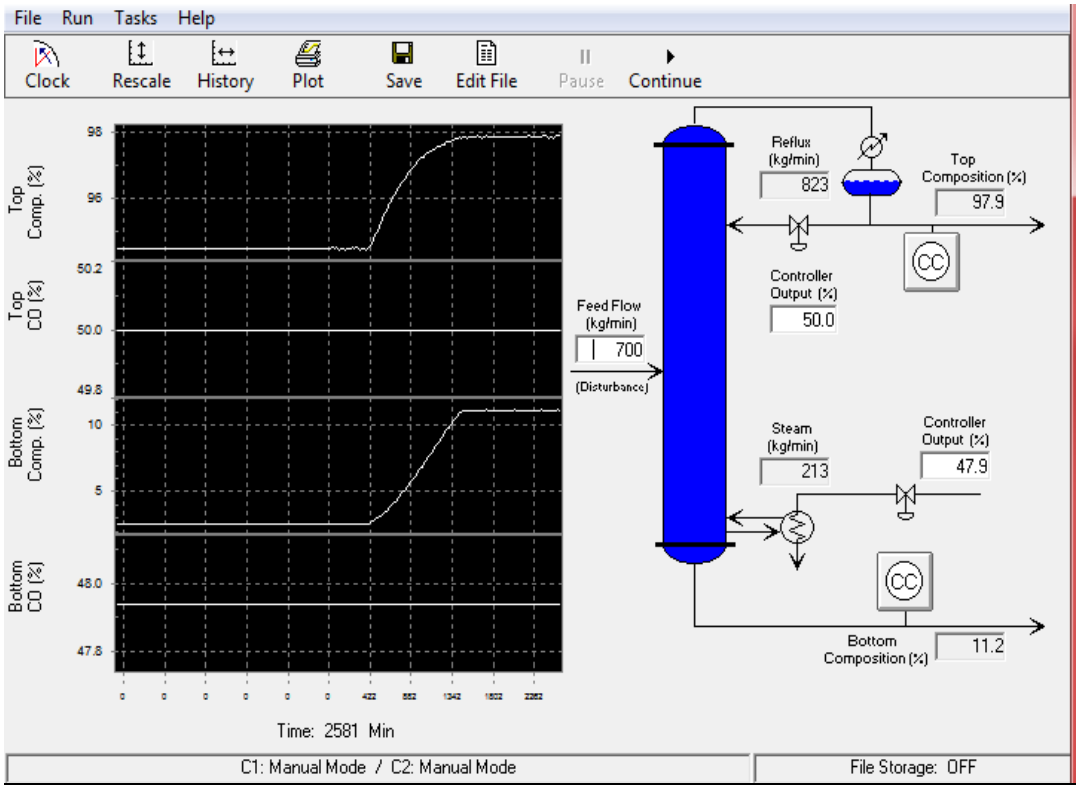
- In order to simulate the system “open loop response”, i will manipulate the feed flow variable.
- On the interfaces this can be accomplished by using the default options of the program.
- By selecting the option "change process disturbance" in the menu “tasks”



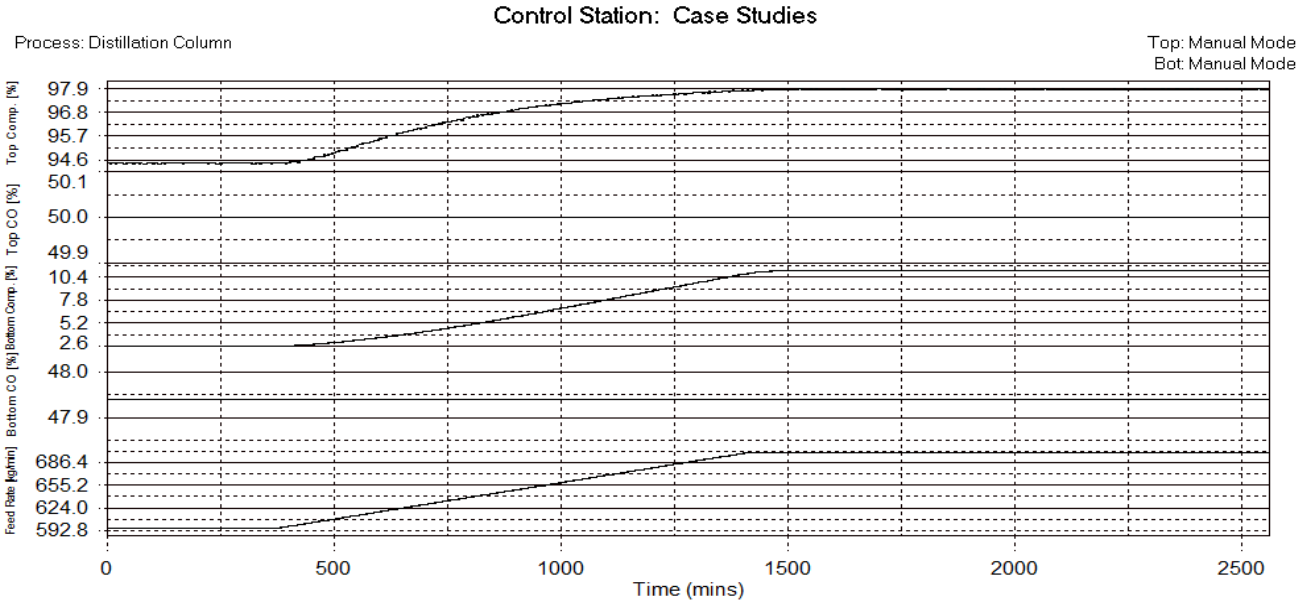
I choose to perturb the system by changing the value of the disturbance from 595.95 kg/min to 700 kg/min (arbitrarily chosen) with a ramp rate set by default 0.10 kg / min / min.



Disturbance variation is analysed in a graph with variables involved.

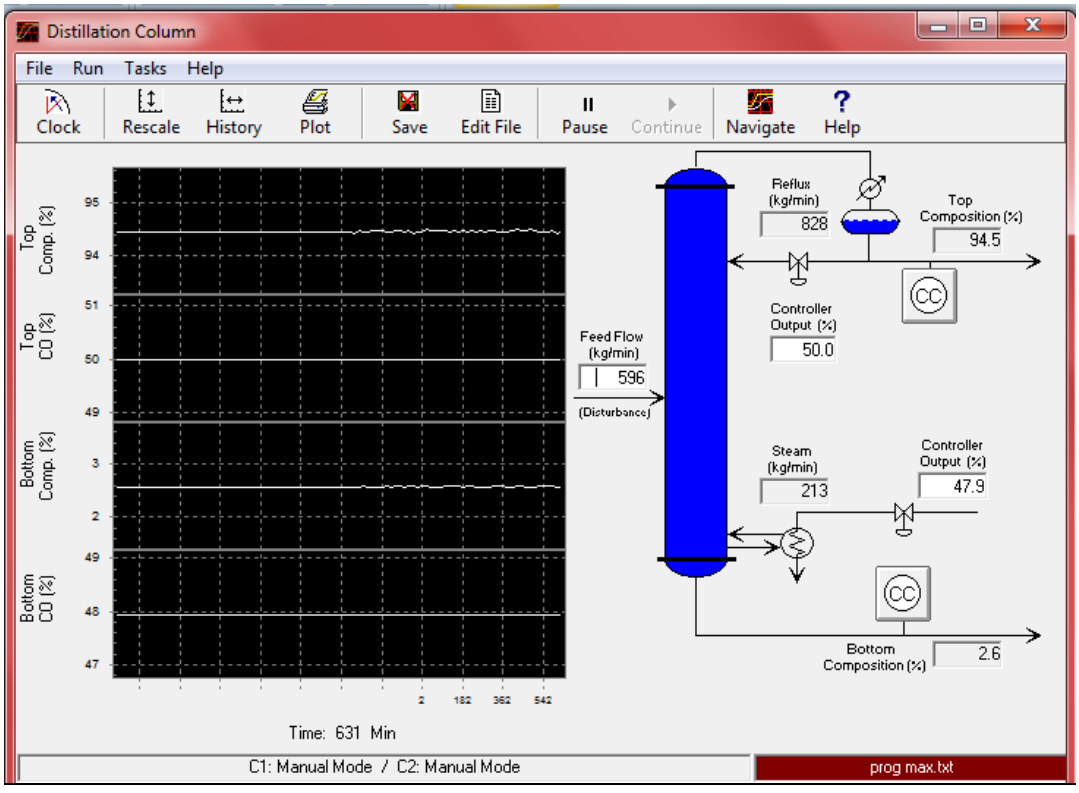


The disturbance has a variation on “limited" ramp. The system, moreover, moves to a new steady state.



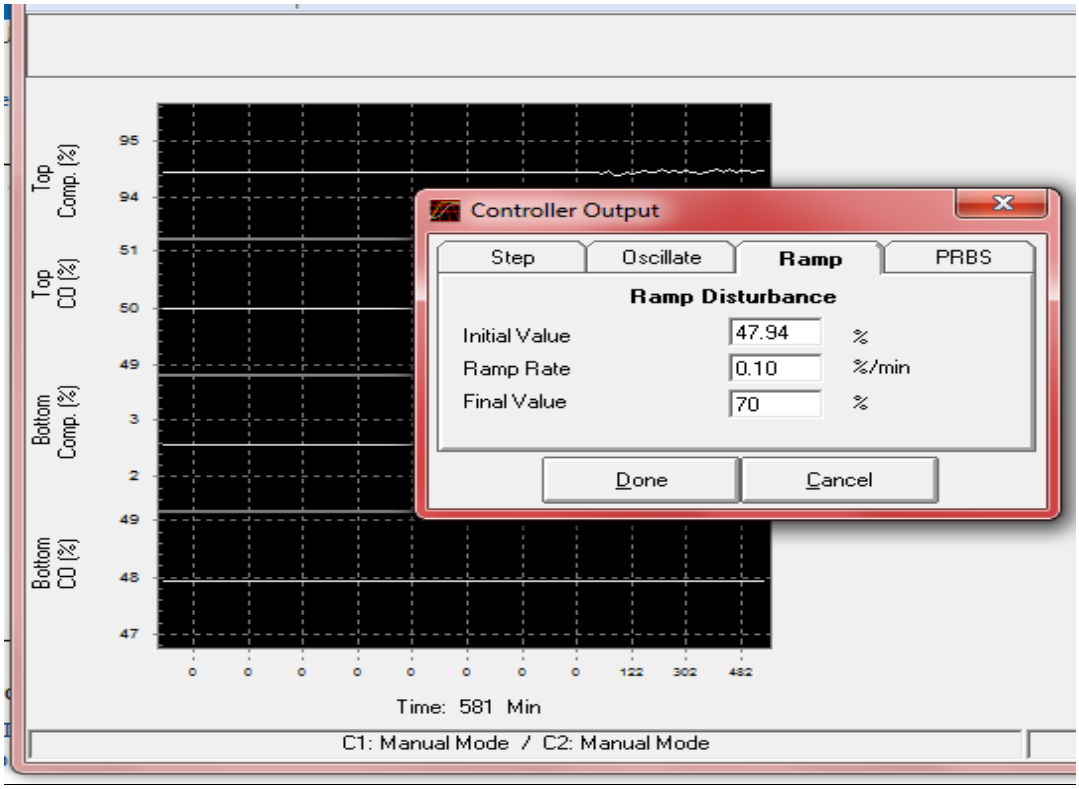
5. simulate the "open loop" dynamic response as a function of one of the *controller outputs*, following a "limited ramp” variation

- In order to simulate the system “open loop response”, i will manipulate the CO (reboiler) variable.
- On the interface this can be accomplished by using the default options of the program.

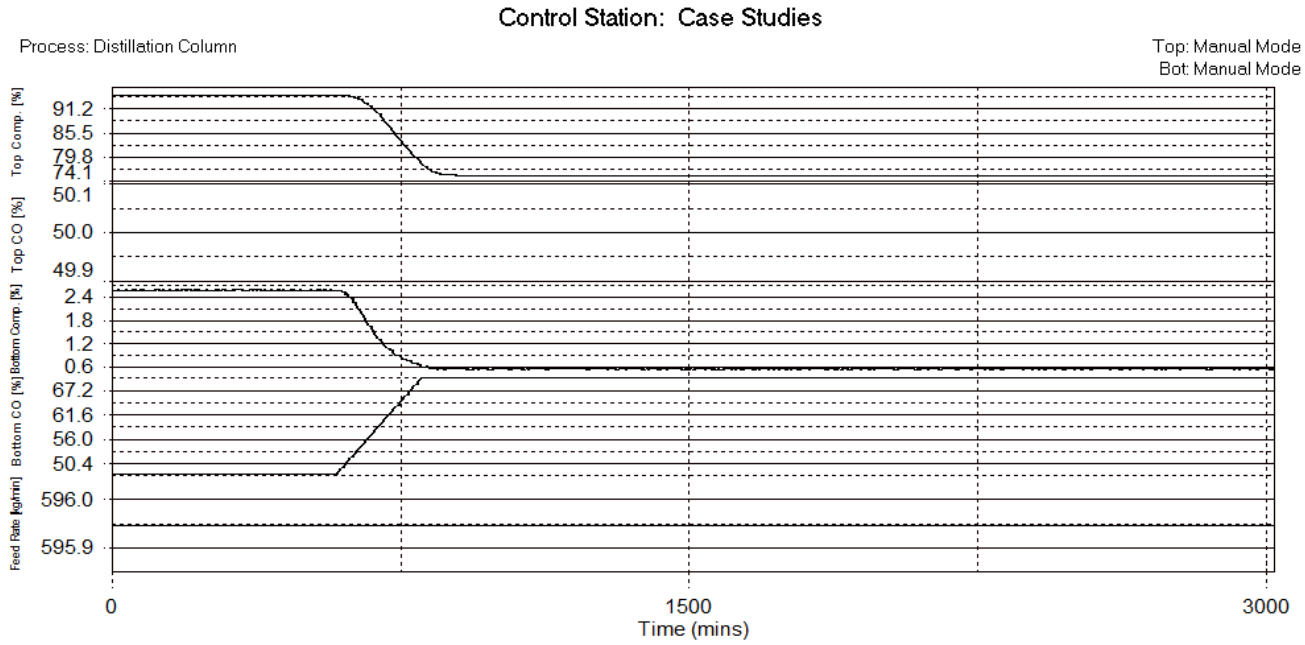


- By selecting the option “bottom: change control output" in the menu “tasks”.

I choose to bring the variable CO (reboiler) from an initial value 47.94% to a new final value of 70% in order to easily compare with the case of step variation.



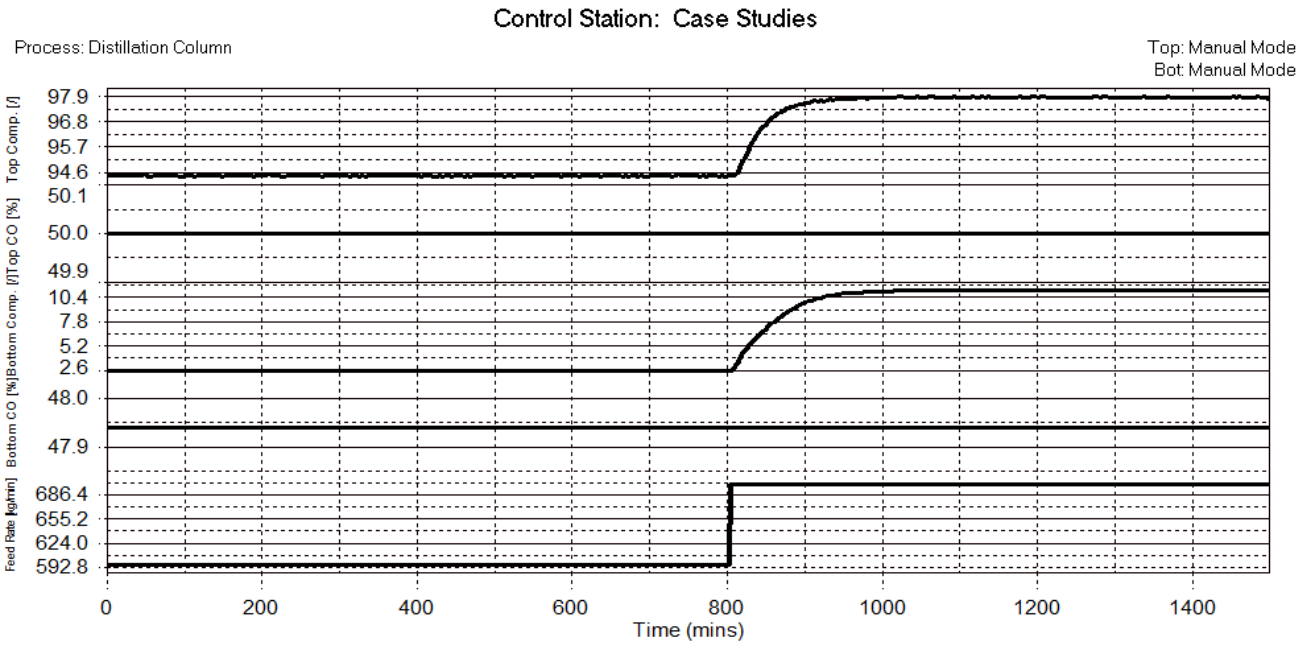
Made the variation, the variables can be represented as a function of time. Following the “limited” ramp, CO moves to new steady state.



6. discuss the "open loop" responses and propose a general comparison

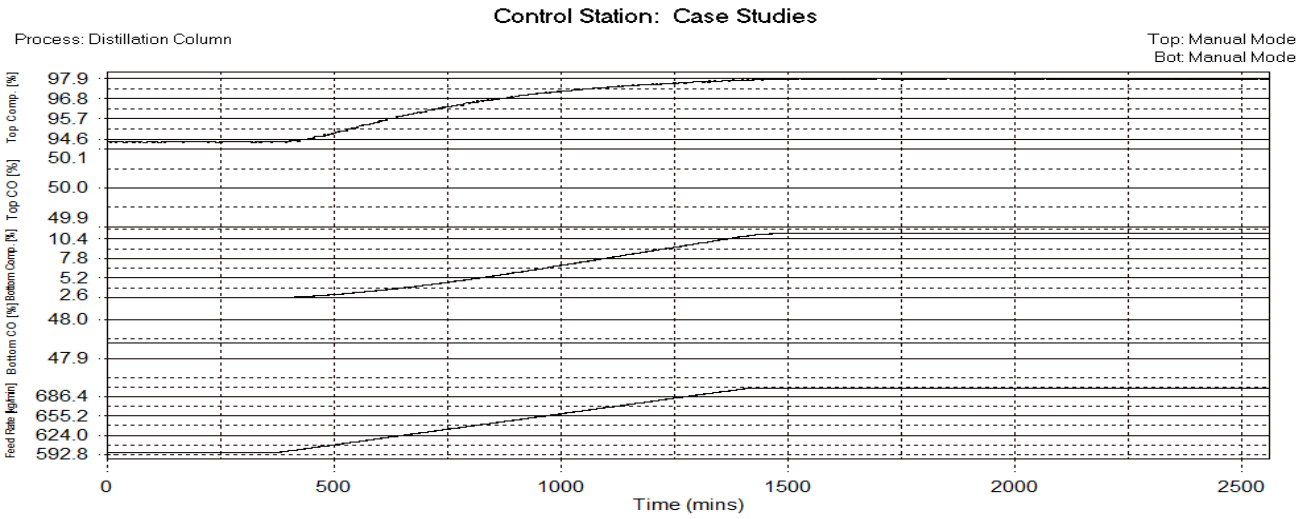
In both cases, that is variation of the disturbance and of CO, it is observed that the system is self-regulating and therefore presents no poles in origin. Making changes, the process moves to a new steady state.

Variation of the disturbance:



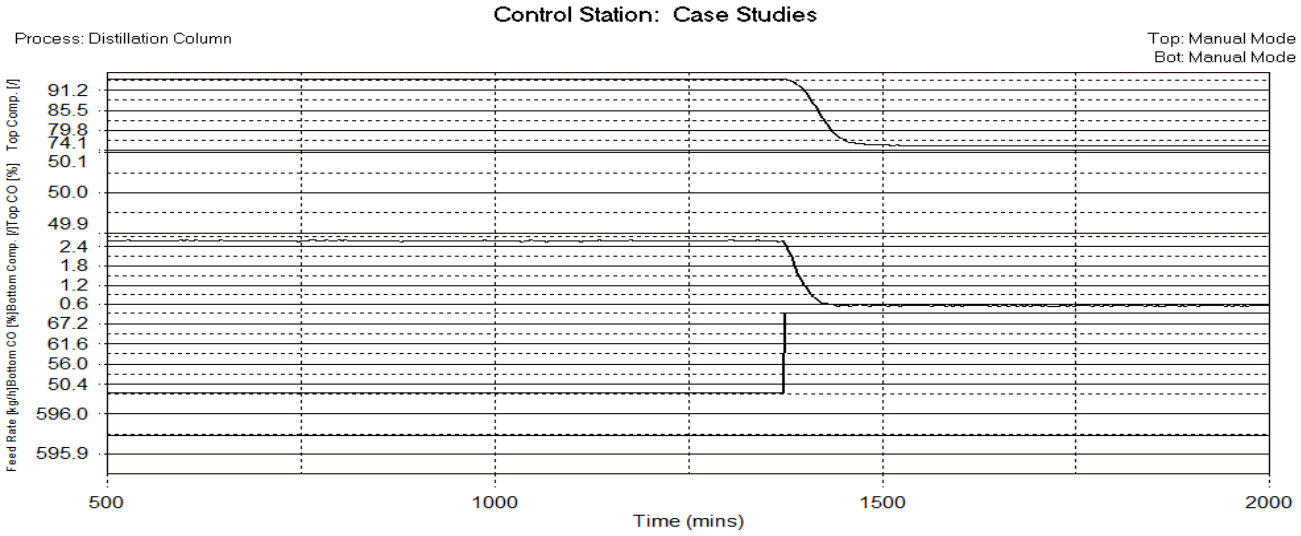
In the first case the variation of the disturbance step involves a variation of the system towards a new equilibrium state. In fact, in the distillation column there will a new value of the composition for both, top and bottom. In particular, the composition increases. Moreover, the values moves in a new steady state asymptotically.

In the second case with a variation of the disturbance to a limited ramp, the system moves to the new steady state value more slowly than the previous case in terms of both conversions top and bottom. The speed to reaches the new steady state is a function of the "ramp rate." An asymptotic behaviour does not observed in reaching the new steady state. The compositions of both the top to the bottom increase.

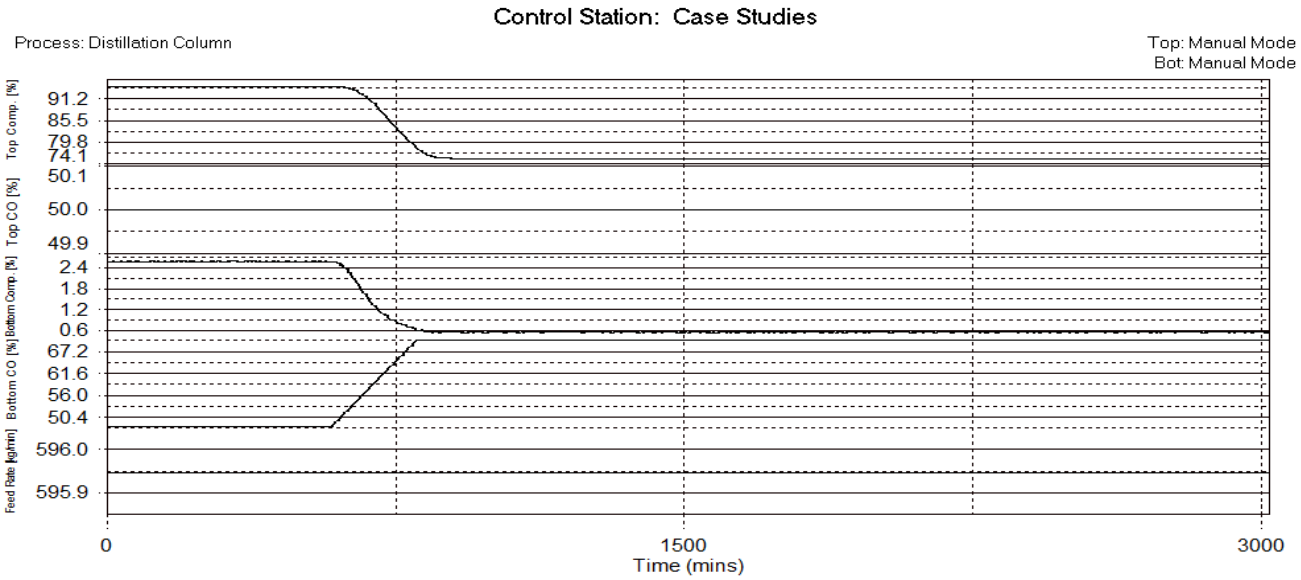


Change in CO:

In the first case with a variation of CO to step the system moves to a new steady state but in this case the CO (reboiler) value is increased and the compositions of both (top and bottom) decreased (see a **reverse acting system**). The values move to a new steady state asymptotically.



In the second case, by varying the CO to limited ramp. the system moves to a new steady state value more slowly and the compositions of both top and bottom decrease.


Control Station: Case Studies
Process: Distillation Column
Top: Manual Mode
Bot: Manual Mode
Top Comp. [%]
91.2
85.5
79.8
74.1
Top CO [%]
50.1
50.0
49.9
Bottom Comp. [%]
2.4
1.8
1.2
0.6
Bottom CO [%]
67.2
61.6
56.0
50.4
Feed Rate [kg/min]
596.0
595.9
0
1500
3000
Time (mins)