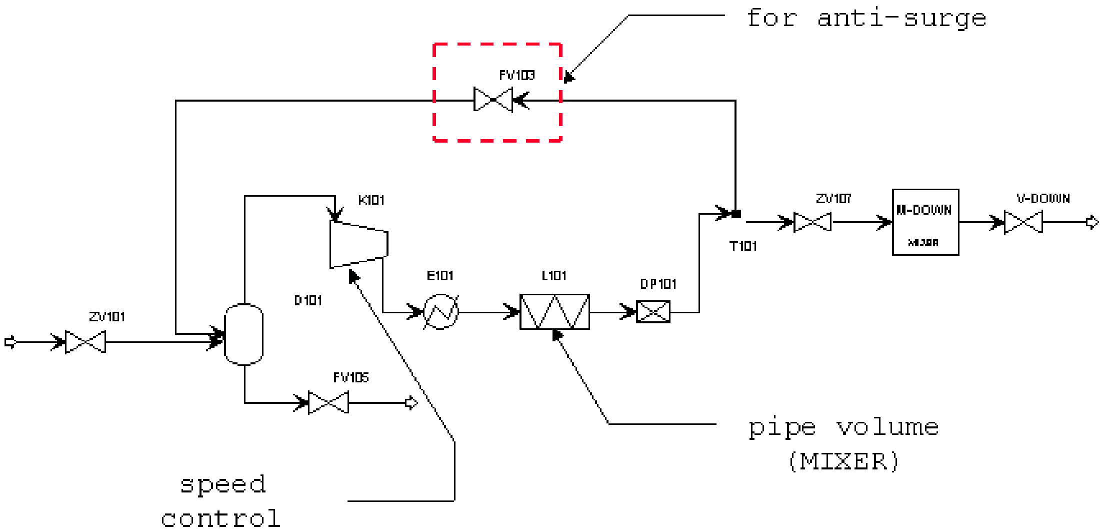
Workshop 302-compressor-anti-surge

Workshop Objectives

- Illustrate how to create a simple anti-surge control on a compressor

Workshop Description

Flowsheeet: A feed stream at 1 bar with methane, ethane and propane is compressed to 2 bar.



Step 1

- Open the file **compr3.bkp** in Aspen Plus.
- Run the simulation
- Export as pressure driven.

Notes about the simulation

- D101 is the knockout drum, to prevent any liquid to enter the compressor. Note that at the initial conditions there are no liquid, which is causing some warnings during the export. The valve FV105 is specified with a valve coefficient, to allow the export.
- The volume of the D101 including the volume of piping for the low-pressure side of the compressor.
- K101 is the compressor, specified with a performance curve giving the head as a function of flowrate, and efficiency as a function of flowrate. The compressor is specified as “dynamic,” i.e., we give the moment of inertia. In the dynamic simulation, the speed will be free, and the mechanical power will be fixed. A controller will be added to manipulate the power and control the speed.

- E101 is a cooler. It is specified with “constant medium temperature,” as to mimic an air cooler. (Avoid the constant duty option, unless you add a temperature controller, as the flowrate may vary dramatically)
- L101 and DP101 represent the volume and pressure drop of the piping on the high-pressure side.
- ZV101 and ZV107 are the isolation valves.
- M-DOWN and V-DOWN represent the volume and pressure drop of the process downstream.
- Finally, FV1-3 is the recycle valve, which will be used to prevent the compressor to go into surge.

Step 2

- Open the file in Aspen Dynamics.
- Change the run mode to initialization.
- Do a run.

Note: It is difficult to trace the source of this type of error. One can look in the group demonstration as the message above is triggered by equations from group 104 to 118. It is actually the group 118:

- Having found the equation, one would then have to know why this is causing a flash error: the saturation pressure is needed for chocking and cavitation calculations.
- pVap_Pressure is the procedure that returns the saturation pressure for given temperature and composition. As the temperature is above the critical point, there is no saturation pressure, hence the problem.
- The solution is to avoid chocking and cavitation calculation, which is done by switching the valve in “Simple” mode.

Step 3

- Open the Configure form for the valve FV105.
- Change the presmode to “Simple”.

Step 4

As the time constants in the process are very short, we will change the units for time to minutes, instead of hours

- Open the Run Options window.
- Change the units of time to “Minutes” for both model and plot.
- Open the Global table.
- Change the parameter “GlobalTimeScaler” to 60 (this means 60 seconds in one minute).
- Run the simulation in Initialization run mode.

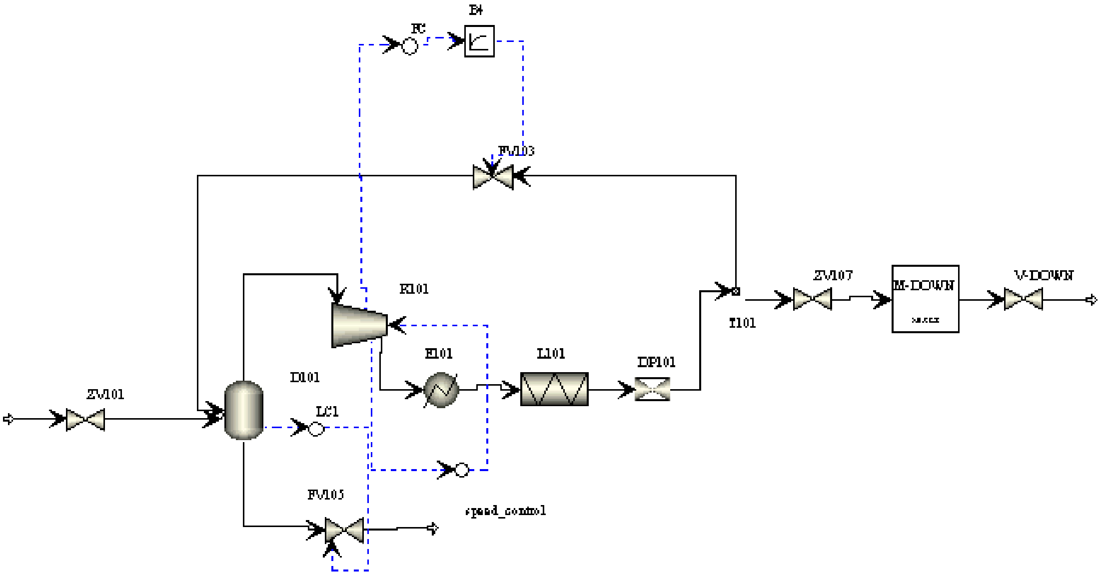
Step 5 (1)

Specify the control system.

- Remove the controller PC2 and the connected control signal.
- Remove the controller PC3 and the connected control signals.
- Create a PID block, name it “speed_control”.
- Connect as PV the compressor speed (ActShaftSpeed)
- Connect as OP the compressor power (Bpower).
- Open the Configure form for the PID.
  - Click on the “Initialize Values” button and set as follows:
    1. Gain = 4
    2. Integral time = 0.5 min
    3. Controller action = Reverse

- Create a PID controller, name it “FC”.
- Connect as PV the compressor approach to surge (perf_curve(1).AvgSrg)
- Connect as OP the valve FV103 position (Pos).
- Open the Configure form for the PID.
  - Click on the “Initialize Values” button and set as follows:
    1. Set point = 15%
    2. Bias = 1
    3. Gain = 1
    4. Integra time = 60000 min
    5. Controller action = Reverse

- On the Range sheet, set the following:
  - Process variable range minimum = 10
  - Process variable range maximum = 20
  - Output variable range minimum = 1e-4
  - Output variable range maximum = 100



Step 6

Valves typically have a short time constant. However, the time contant may be important to consider for this type of study.

- Restart the simulation.
- Create a Lag_1 block.
- Reconnect the signal the output of the Lag_1 block to the valve position.
- Open the Configure form for the Lag_1 block and set the time constant to 5 seconds.
- Restart the run.
- If you close the valve ZV107 faster (i.e., in 6 seconds or 0.1 minute), you will observe that with a time constant of 5 seconds, the compressor goes into surge. The simulation will then fail to converge.

Dynamic Simulation

We want to know recycle stream flowrate to prevent surge circumstance when the feed flowrate abruptly is reduced due to the sudden close of ZV 101 valve.

- Initialize the dynamic run.
- Do a dynamic simulation during 2 minutes.
- Change the ZV 101 valve opening percent to 10% from full open.

Note: Assumptions used in Aspen Dynamics compressor model are not meant to be valid in the surge region.

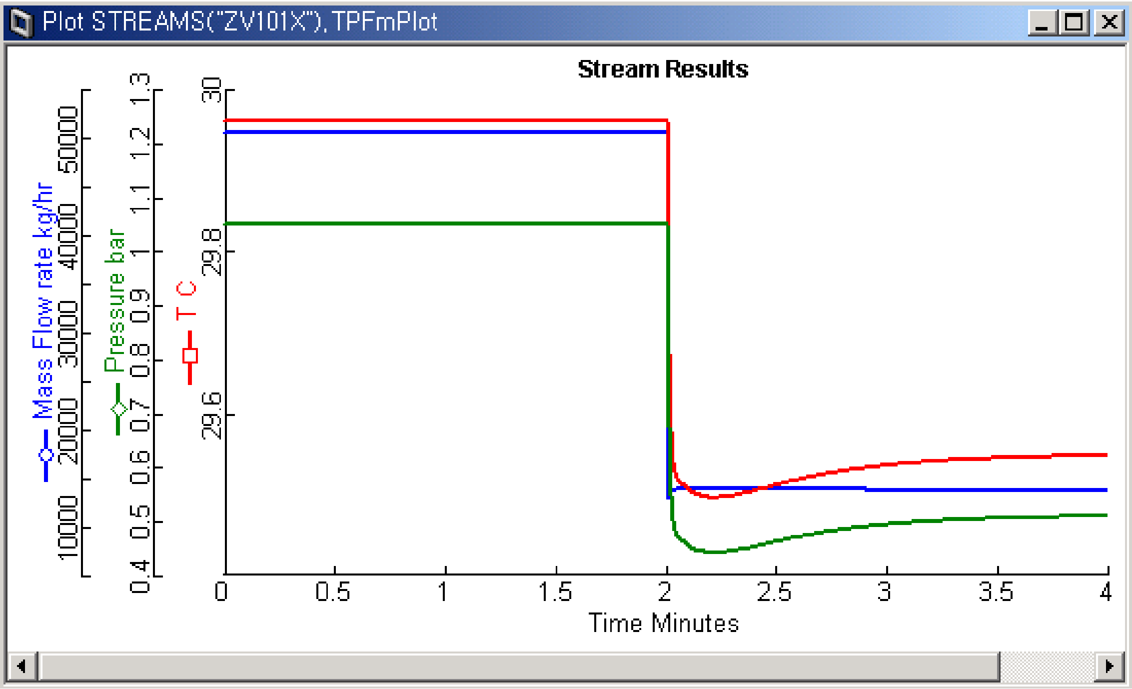


Fig: Feed stream flow valve out stream flowrate change when the valve opening percent abruptly is changed to 10%.

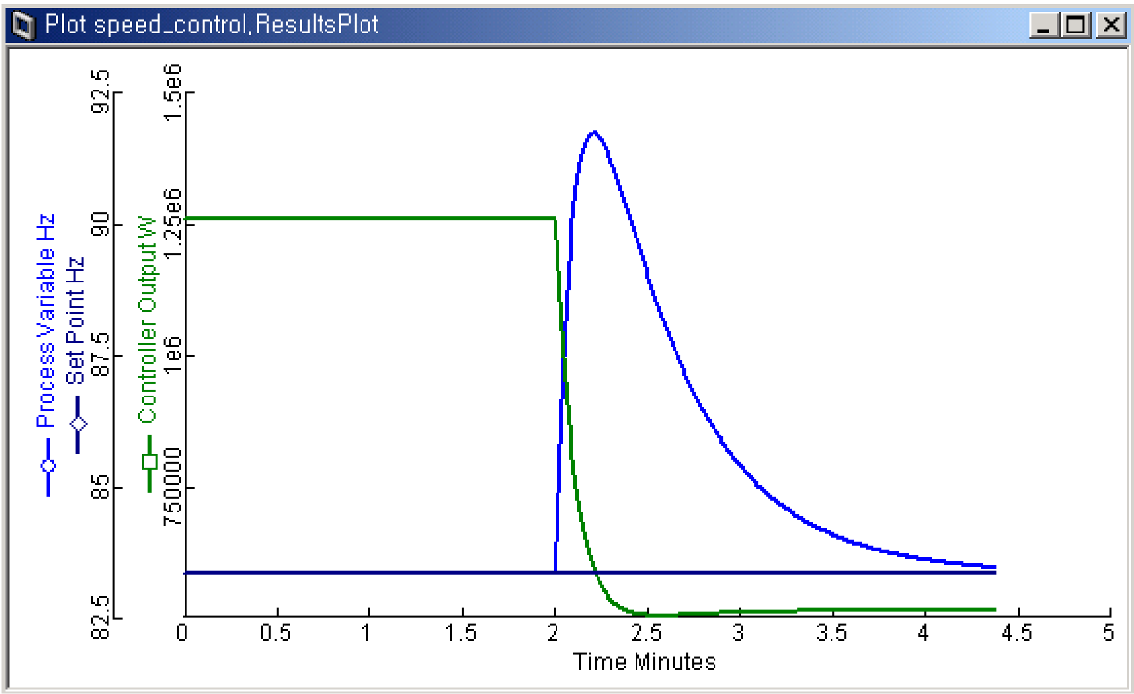


Fig: Compressor speed-controller control action change versus time

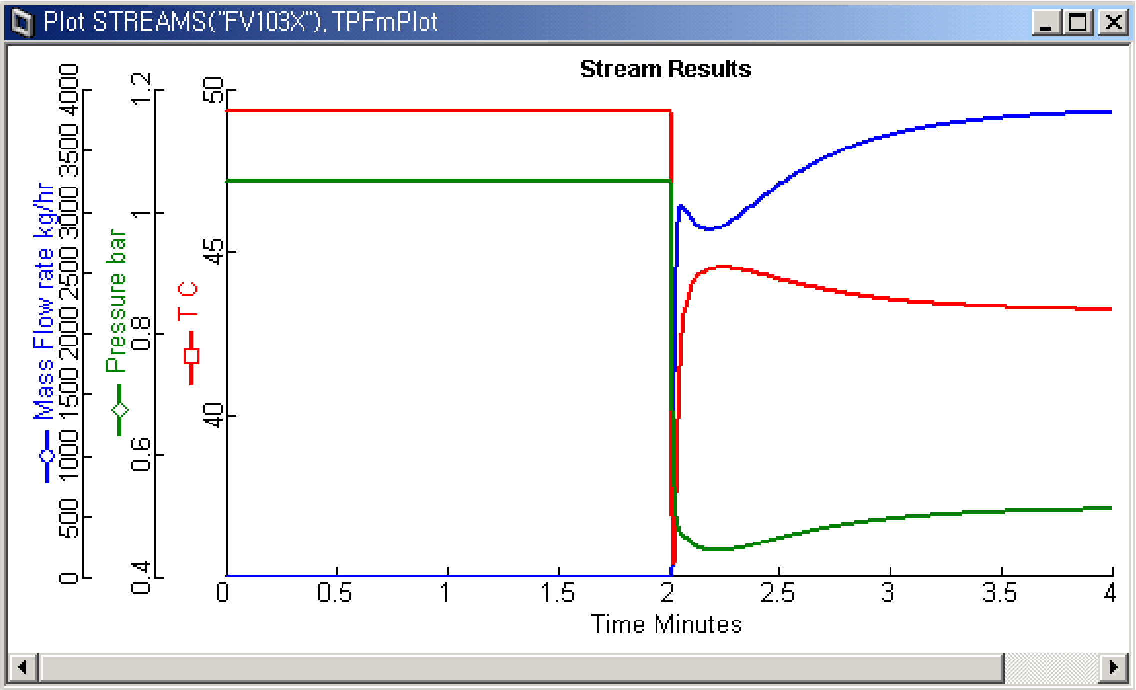


Fig: Recycle stream flowrate change which prevent compressor from surge when the valve opening percent abruptly is changed to 10%.

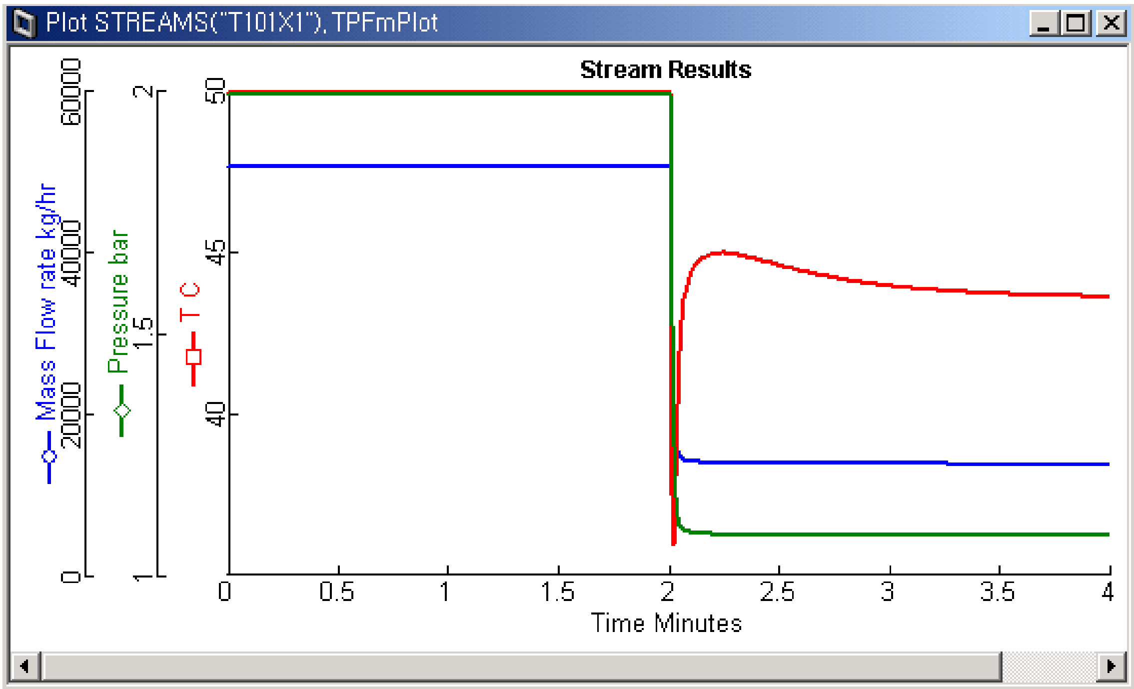


Fig: Outlet stream flow valve out stream flowrate change when the valve opening percent abruptly is changed to 10%.