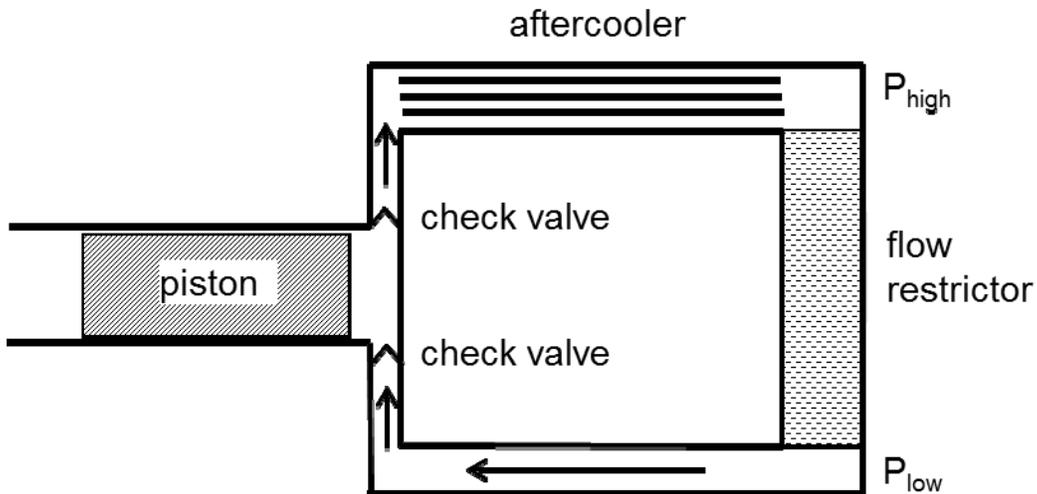


# Sage Model Notes

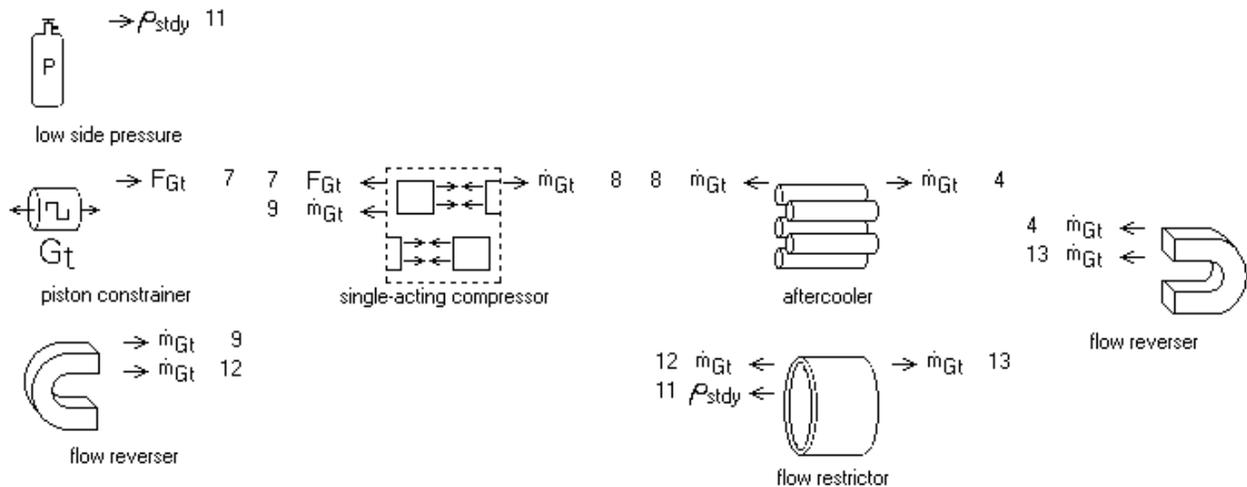
## GasCompressor.ptb

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A piston-type gas compressor with intake and discharge check valves and a closed flow circulation loop:

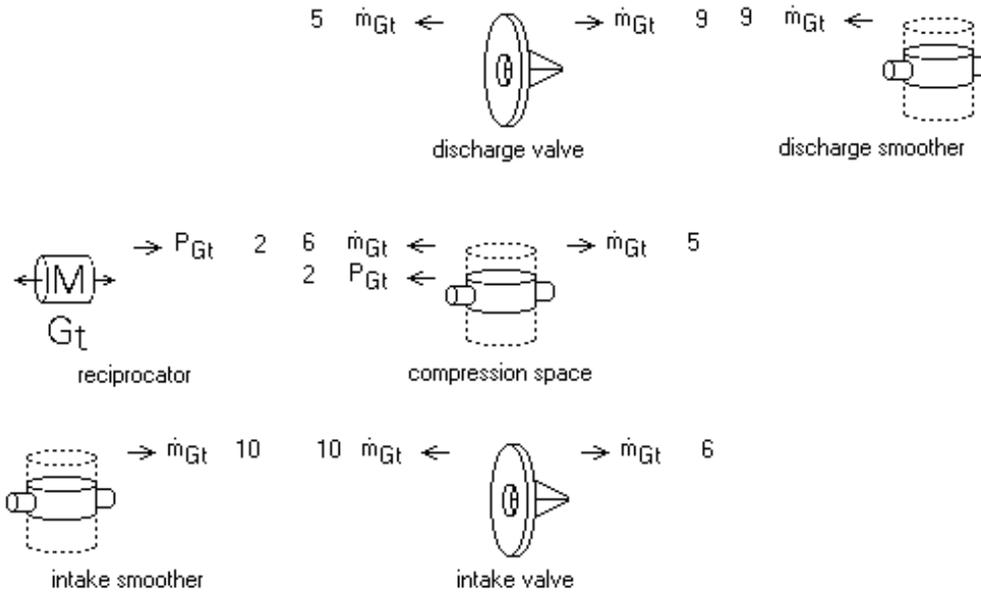


The root-level Sage model looks like this:



A pressure reference anchors the suction pressure and a flow restrictor determines the discharge pressure. The aftercooler removes the heat of compression. The piston constrainer attaches to a reciprocating mass within the single-acting compressor submodel. In the present model the piston constrainer determines the piston amplitude but it could be replaced with another type of force actuator, depending on modeling requirements. The number of time nodes is 11 (root input NTnode), compared to the usual 7 to better resolve the higher harmonics of the solution.

The single-acting compressor submodel looks like this inside:



The reciprocator modulates the volume of the compression space via an area attachment causing the pressure to rise and fall. When the pressure rises above the pressure in the discharge smoother gas flows through the discharge valve. When the pressure falls below the pressure in the intake smoother gas flows through the intake valve. The maximum discharge pressure is determined by the piston swept volume relative to the compression space volume and the flow resistance of the flow restrictor. The purpose of the two smoother components is to filter out the abrupt gas flows through the check valves so the flow through the outer loop is nearly steady.

User-defined inputs in the compressor submodel determine many of the inputs of the components inside:

### Inputs

Dpis	piston diameter (m)	2.5000E-02
XpMax	maximum piston amplitude (m)	5.0000E-03
Dchkvalve	check valve open diameter (m)	3.0000E-03
AratChkvalve	check valve closed/open area (NonDim)	1.0000E-02
PopenChkvalve	opening pressure (Pa)	5.0000E+03

For example, in the compression space:

### Recasts

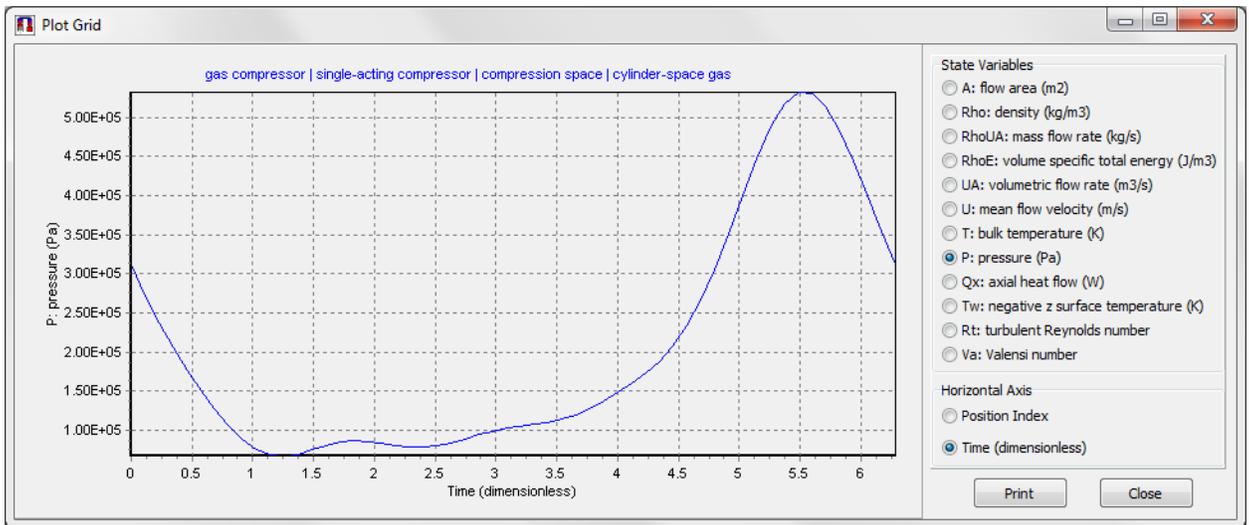
$$\begin{aligned} \text{Length} &= XpMax \\ \text{Swet} &= 2 \cdot A_{pis} + \pi \cdot D_{pis} \cdot \text{Length} \\ \text{Volume} &= A_{pis} \cdot XpMax \end{aligned}$$

And in the check valves:

### Recasts

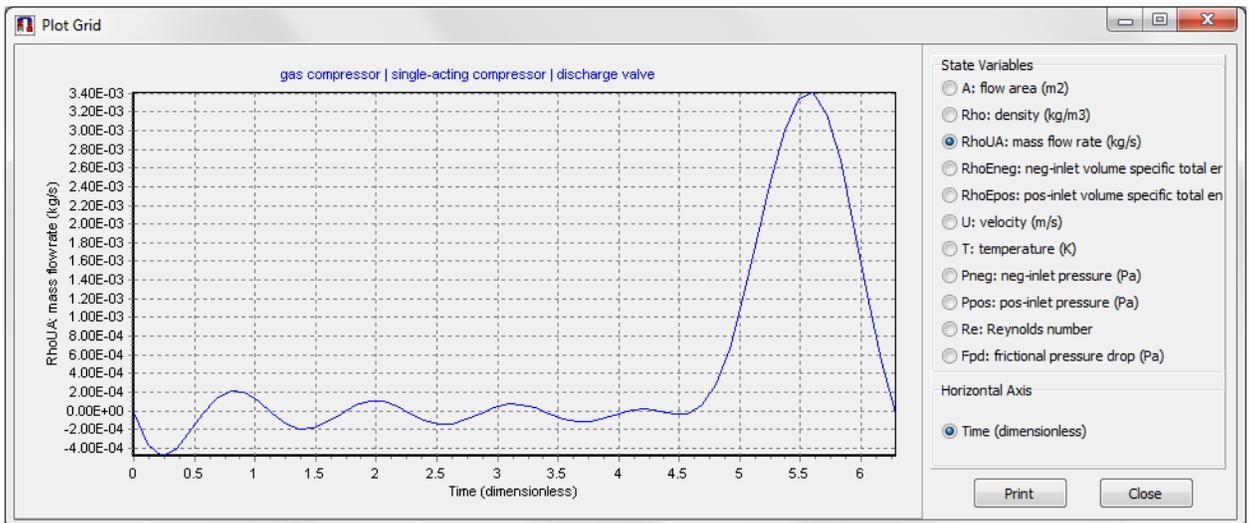
$$\begin{aligned} D_{orf} &= D_{chkvalve} \\ A_{ratio} &= A_{ratChkvalve} \\ P_{open} &= P_{openChkvalve} \end{aligned}$$

For the current model inputs the pressure variation in the compression space looks like this:



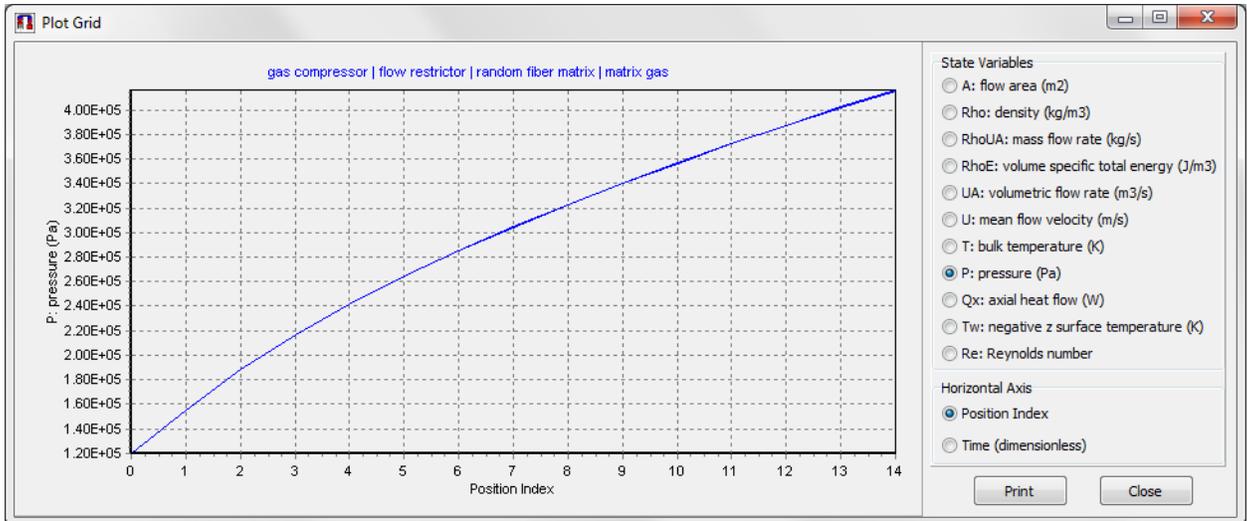
The minimum volume is at dimensionless time  $2\pi$ .

The mass flow rate in the discharge check valve looks like this:



The wiggles are an artifact of the Fourier series interpretation of the plotted value and an indication that even for  $NT_{node} = 11$  (5 harmonics) the abrupt changes due to sudden check valve openings are not completely resolved.

The pressure variation in the flow restrictor is smoothed out by the volume in the discharge smoother but varies with position like this:



The pressure varies smoothly from the high-side pressure of about 0.4 MPa to just above atmospheric pressure.

## Convergence

Because of the abrupt flow changes in the check valves Sage does not converge as reliably with this model as it does for a model with smoother mass flow and pressure variations. If you make a significant change to some of the model inputs or reinitialize the solution it may not converge.

To achieve convergence you may have to temporarily increase the closed/open area ratio for the check valves from the current 0.01 to, say, 0.1 by setting the AratChkvalve input of the compressor submodel. Under this change there is more flow through the check valves when they are *closed*, which smooths out the mass flow rate and helps convergence. You may also have to temporarily reduce piston amplitude. After you achieve convergence you can then gradually reduce AratChkvalve to reduce back-flow to an acceptable level and increase piston amplitude to the design value.