Sage Model Notes

VentHole.scfn

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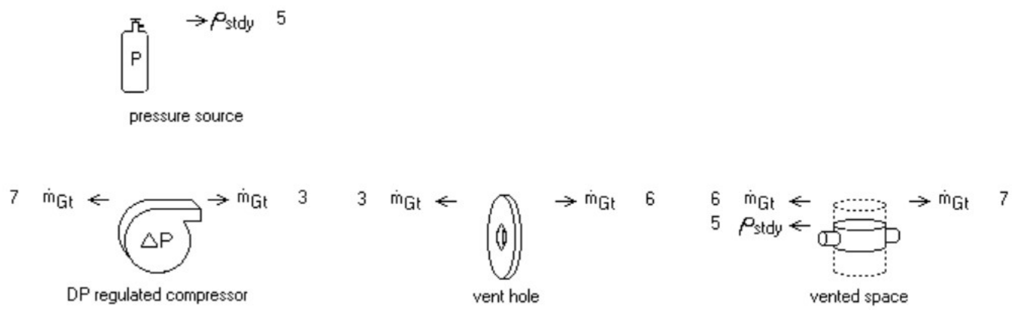
A somewhat abstract model designed to estimate the size of a vent hole of the type used to purge air from or charge with helium a separate volume that shares a common boundary with a variable-pressure space. For example, the interior of a hollow displacer shell used in a stirling engine. If the vent hole is too small it will take an excessive time to purge the volume prior to final charging with the working gas. If too large the AC gas flow through the vent hole in operation will adversely affect the PV power input or output of the stirling cycle.

The Sage model looks like this:



The DP regulated compressor is just a convenient way to impose a sinusoidal pressure drop across the vent hole (sharp-edged orifice). The vented space (generic cylinder) imposes zero pressure drop by its nature. If the vent-hole were part of a larger model the DP regulated compressor would be replaced by some component of the model with a significant pressure swing (e.g. a variable-volume compression or expansion space). The return path ($\dot{m}_{Gt}$ arrow 7) would be optional. It is used in this model because the DP regulated compressor requires two $\dot{m}_{Gt}$ connections.

Root-model

Driving the model are inputs:

```
Freq            frequency (Hz)                          1.000E+02
Gas             working gas                             Ideal Helium
P0              mean pressure (Pa)                      2.000E+06
Pratio          Pamp/P0 (NonDim)                        1.000E-01
```

The last two are user-defined inputs in terms of which the inputs for the pressure source and DP regulated compressor are recast to:

```
Pcharge = P0
```

and

```
FDP = 0.000E+00...
  (Pratio * P0) Amp
  (0.000E+00) Arg
```

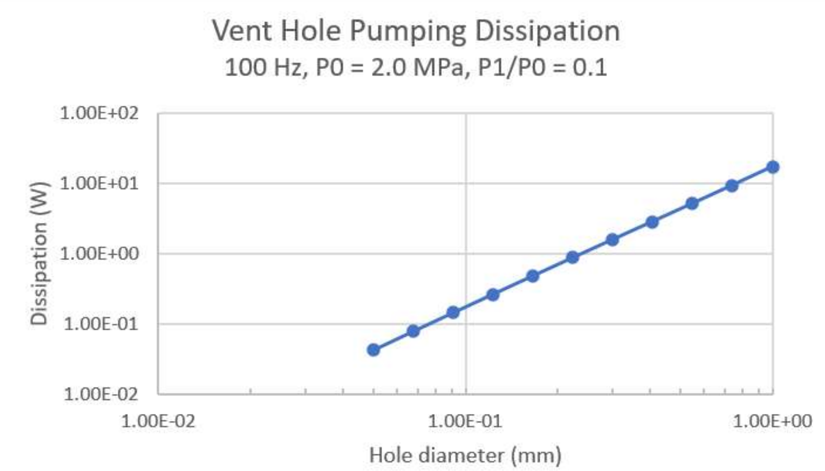
In other words the pressure rise across the compressor is automatically set to a constant fraction of the charge pressure (Pratio). The value Pratio = 0.1 is representative for most stirling-cycle machines.

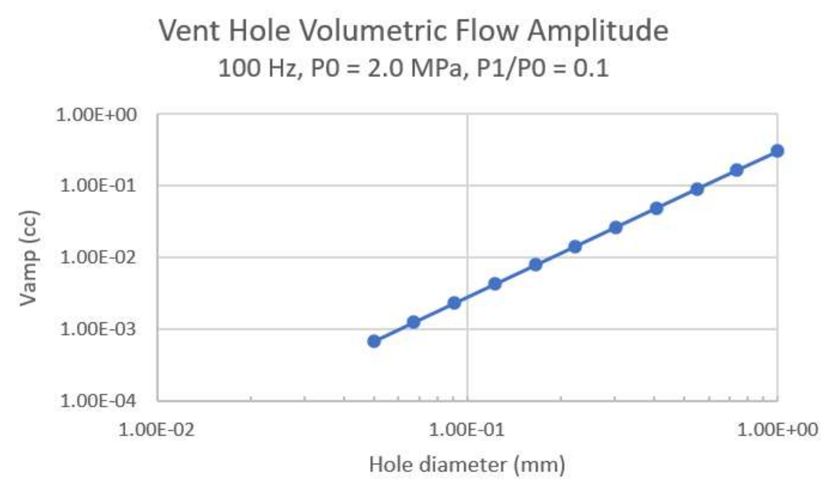
Vent Hole

The vent hole component includes some outputs of interest to the designer:

```
Rho0            mean density                          3.161E+00
  1 / Gas.v(FT.Mean, FP.Mean)
Wpumping                                              4.236E-02
  AEfric
MdotAmp         mass flow rate amplitude              1.357E-06
  FRhoUA.Amp.1
Vamp            volumetric flow amplitude             6.832E-10
  MdotAmp / ( 2*Pi*Freq*Rho0)
```

Of these the most useful are the pumping power Wpumping and volumetric flow amplitude Vamp. These are plotted below for a representative case. The model is setup to map the orifice diameter over the range shown in the plots.





The pumping dissipation can be understood as a parasitic loss to the mechanical power flowing into the stirling cycle working gas (in the case of a cooler) or out of it (in the case of an engine). To gauge this significance of this loss it can be compared to the total net input or output power.

The volumetric flow amplitude can be understood by comparing it with the volumetric displacement amplitudes of the compression or expansion spaces of the stirling cycle. You might imagine the vent-hole volumetric flow as produced by the displacement of a tiny piston moving with flow through the vent-hole, which is in direct competition with the physical piston displacements driving the compression and expansion spaces.

For example, a multi kW stirling engine might have an expansion space volumetric displacement of several hundred cc. In that case a vent hole volumetric flow amplitude of 1 cc would be relatively insignificant. For a small cryocooler with an expansion space volumetric displacement of <1 cc it would be catastrophic.