Sage Model Notes

AlphaEngine.scfn

D. Gedeon
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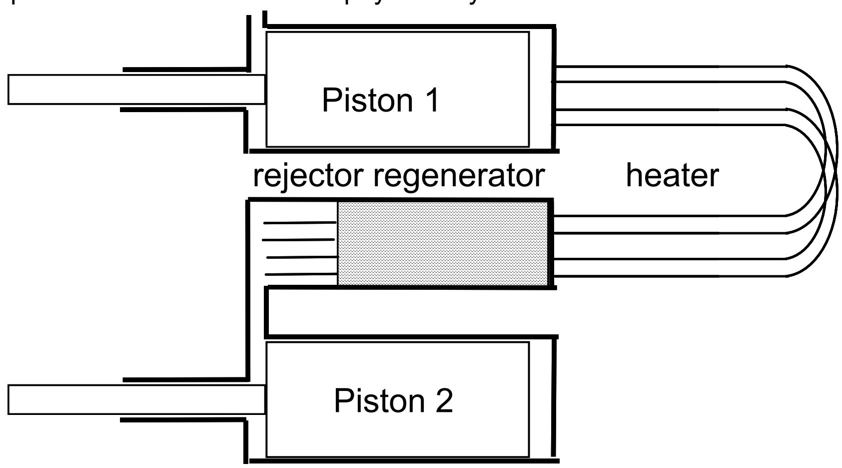
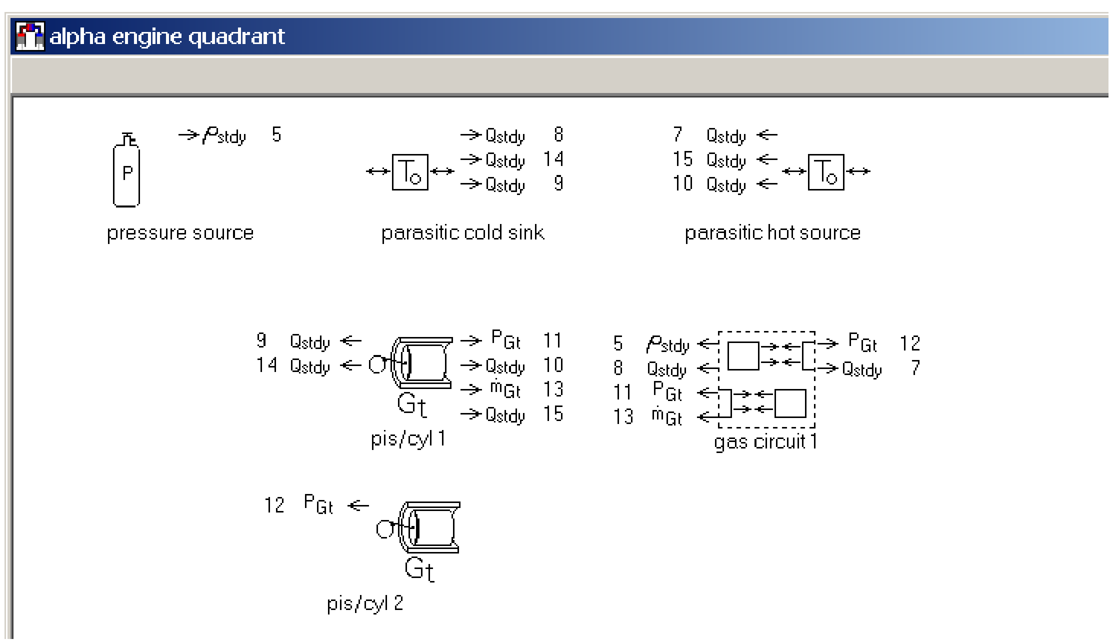
A model for an alpha-type (double acting piston) stirling engine. Such an engine generally employs three or four identical pistons driving identical gas circuits, with piston phases offset by 120 or 90 degrees from one to the other so as to implement identical stirling cycles, apart from phasing. This model simulates only one of the gas circuits bounded by two of the pistons. A schematic of the physical layout looks like this:



The Sage model looks like this at the top level:



The *pressure source* establishes the mean cycle pressure.

The *parasitic cold sink* and *parasitic hot source* anchor the endpoints of various thermal conduction paths in the model. These are the pressure-wall, piston shell and shuttle-heat transfer within *pis/cyl 1* and the regenerator canisters within *gas circuit 1*. They do *not* establish the heater and cooler tube-wall temperatures within *gas circuit 1* (*see* below).

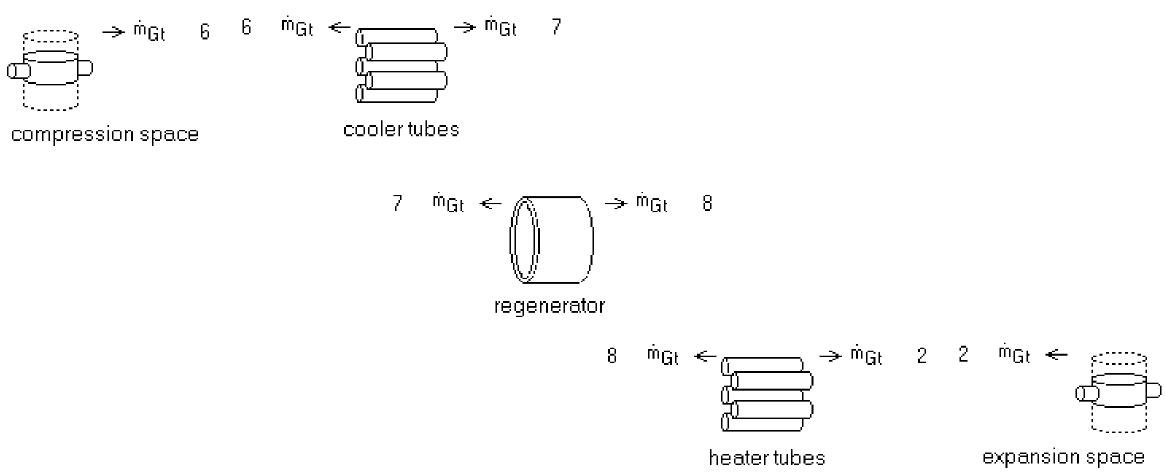
Component *pis/cyl 1* represents the hot piston dome of one piston (including the appendix gap between the dome and cylinder wall). The piston dome connects to (displaces volume in) the expansion space within *gas circuit 1*. More on this below.

Component *pis/cyl 2* represents the cold face of another piston. It connects to the compression space within *gas circuit 1*. The phasing of piston 2 is advanced 90 degrees relative to piston 1 and that is what makes this a model of a 4-piston alpha engine. If it were advanced by 120 degrees the model would represent a 3-piston alpha engine, and so on.

It is be possible to model all four pistons and gas circuits of a complete alpha engine. To do this you would first break the connections sticking out of the *pis/cyl* components and the *gas circuit 1* component. Then delete *pis/cyl 2* because it does not have a piston dome. Then make three additional copies of pis/cyl 1 and gas circuit 1 (copy and paste tool), renaming them 2, 3, 4. Then re-connect everything, adding new attachments to the parasitic temperature components as needed. I have never done this but one reason you might want to would be to model leakage across piston seals from one gas circuit to the next. The current model cannot do that because there is only one gas circuit. You would have to add piston seal components in series with the appendix components in each *pis/cyl* to do that. Another reason would be to model small differences between gas circuits to see What difference it would make. Beware that the number of pressure source components required depends on whether or not the gas circuits are connected by leakage. If they are connected then only one pressure source is required (allowed) lest the solution be over-determined. If they are not connected they you will need a separate pressure source connected to each one.

Gas Circuit 1

The gas circuit 1 submodel contains a number of components implementing the stirling cycle. Essentially a linear arrangement of gas-containing components between a compression space and an expansion space. The volume displacement provided by piston 2 drives the compression space. Likewise, piston 1 drives the expansion space:



Cooler Tubes

All the tube are grouped together into a single component. In this model the tube walls are isothermal, as established by input *Tinit*. In other words, the gas sees a fixed surface temperature (which may vary with position). It is possible to add solid thermal conduction paths for more realism or to avoid having to change *Tinit* to change the cooler temperature. See the examples in the Stirling Model Class Guide for more information.

Regenerator

Thermal conduction down the regenerator canister wall *is* part of the model. Within the canister are sub-components representing the canister walls and the regenerator matrix. Canister wall heat-flow connectors have been promoted to the root level for connection to the source and sink temperatures. The regenerator matrix is thermally isolated from the canister walls (no transverse heat flows between the two are modeled).

Heater Tubes

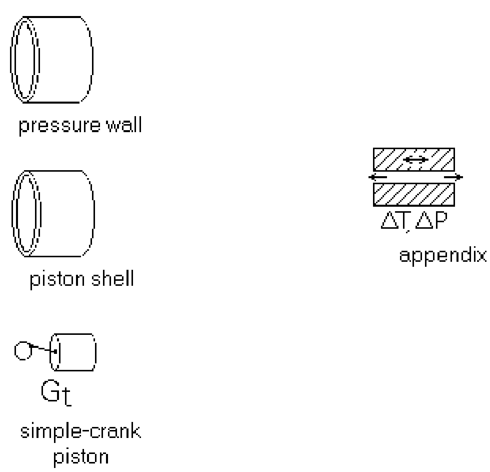
Like the cooler tubes, the heater tubes are grouped together into a single component. They too are modeled with isothermal wall boundary conditions, established by input *Tinit*.

Compression and Expansion Spaces

Within these components are variable-volume gas spaces exchanging heat with *thick surface* wall components. Heat is exchanged back and forth between the gas and solid walls but the walls are thermally isolated from anything else, so that the time-averaged heat transfer is zero. In this case the average wall temperature adjusts accordingly as part of the solution process and input *Tinit* establishes only the initial temperature.

Pis/Cyl 1

The *pis/cyl 1* component contains the same components as the *pis/cyl 2* component with the addition of an appendix gap component:



The *appendix* models the annular gas gap between the piston dome and cylinder wall, including the combined conduction of the two walls and the shuttle heat transfer mechanism produced by the thermal interaction between them as they move relative to each other. One end of the appendix gap connects to (gas flows to) the expansion space within gas *circuit 1* and the other is closed, as if there is a perfect piston seal. The conductive surface within the *appendix* (not shown) gets wall thickness and material information from the built-in *pressure wall* and *piston shell* components in order to implement a combined wall conduction model.

The *simple-crank piston* models the kinematic motion of the piston and also the displacement (frontal area attachment) produced by the piston dome.

Bottom-Line Outputs

A number of special user-defined outputs keep track of bottom-line PV power and heat flows:

Root Level	
Wpv	Net PV power delivered to pistons
Qin	Heat input to heater + parasitic source
Qrej	Heat rejected to cooler + parasitic sink
Eff	Indicated efficiency
Parasitic Hot Source	
QparaSource	Heat to parasitics
Parasitic Cold Sink	
QparaSink	Heat to parasitics
Cooler Tubes	
Qcooler1	Heat to gas
Heater Tubes	
Qheater1	Heat to gas
Pis/cyl 1	
Wpis1	PV power to piston
Pis/cyl 2	
Wpis2	PV power to piston