Guide to Sample Models

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With the introduction of the SCFusion model class in Sage version 13, all the sample models from previous Stirling, Pulse-Tube and LowT-Cooler model classes, along with many new sample models, have been combined together under one folder. This document replaces the "How Do I Model . . . " chapter of the previous versions of the Sage User's Guide. The idea is to substitute actual models for previous instruction lists and make it easier to add new sample models from time to time without the need to update the book-size Sage User's Guide.

File folder names are organized according to a taxonomy derived from my own experience in modeling stirling-cycle and related machines (some only distantly related). The remainder of this documents is intended to help you quickly locate a sample model close to what you want to model. Once you find a model you can open it with the Sage GUI and interact with it directly. You can also read about how the model works and the physical hardware it represents in the pdf documentation file accompanying each model under the same filename.

Contents

1 _Tutorial

A simple moving-part model that illustrates the main features of the Sage interface common to all models. New users of Sage should start with this model.

SpringMassDamper Spring-Mass-damper resonant system

2 MovingParts

More complicated moving parts of potential utility.

MotionSnubber Using the motion snubber component to limit the motion of a reciprocating mass driven by a forcing function of increasing amplitude.

RotatingMechanism Isolated rotating mechanism comprising flywheel, kinematic linkage and reciprocating piston.

3 ElementsThermoModels

Examples of some of the common thermodynamic elements found in larger thermodynamic models.

HeatExchangers-SimpleIsothermal Isothermal duct-type heat exchangers.

HeatExchangers-ThermalConductors Specific heat exchanger geometries using conductive-surface and distributed-conductor components for modeling solid thermal conduction paths, with appropriate inputs recast in terms of user-defined variables.

HeatExchanger-ConductiveMatrix Variation of a porous-matrix heat exchanger where the matrix acts as a conduction path to the outer perimeter, which is held isothermal.

HeatExchanger-ExternalPath Heat exchanger model that anchors the temperature by thermal connection to an ultimate heat source or sink located in an external component.

HeatExchanger-JetImpingement Models the heat transfer produced by fluid jets impinging on a solid wall surface.

HeatExchanger-PwallToInternalFins An externally heated (cooled) pressure wall with annular copper block thermally bonded to a pressure wall ID.

RegenerativeDisplacer-Cylinder Regenerator housed inside a moving displacer.

HeatExchangers-CounterflowRecuperative Thermally connecting two gas domains together using intermediary thermal solids.

Piston-ClearanceSeal Stand-alone piston with clearance seal modeled with the composite free-piston and cylinder component.

HollowDisplacer-Cylinder Hollow-shell displacer moving within a cylinder.

OpposedPistonCompressor Gas pressure-wave generator that provides an AC gas flow produced by two opposed reciprocating pistons.

Regenerator-GenericParallelFiber Generic regenerator component used to model a parallel-fiber matrix not available as a built-in matrix option.

VariableVolumeSpace Generic cylinder component used to model a variable-volume compression or expansion space.

VentHole 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.

4 Compressors

Isolated models of compressors that provide pulsatile DC flow between a low-side and high-side pressure.

GasCompressor Piston-type gas compressor with intake and discharge check valves and a closed flow circulation loop.

GasCompressorTimedValves Piston-type gas compressor with time-dependent intake and discharge valves and a closed flow circulation loop.

5 StirlingCycle

Models for various arrangements of engines or coolers based on the stirling thermodynamic cycle, classified according to the type of expander.

5.1 Piston-BufferTube

So called pulse-tube coolers.

4KThreeStage_RegenSizer Simplified three-stage 4 K cryocooler with idealized expander volumes in each stage, designed to allow relatively fast regenerator sizing without worrying about the detailed components providing the expander functionality.

PulseTubeSizer Stand-alone model of a pulse tube (buffer tube) with downstream pneumatic components designed to adjust the acoustical impedance.

5.1.1 CoAxial

CoAxPTR Single-stage pulse-tube cooler with pulse-tube arranged co-axially within an annular regenerator.

CoAxPTRRadialInteraction Variation of model CoAxPTR, that models the radial thermal interaction between the pulse-tube wall and regenerator matrix.

5.1.2 InLine

ThreeStage 4 K three-stage high-frequency (30 Hz) pulse-tube cryocooler.

InLinePTR Single-stage pulse-tube cooler with pulse-tube arranged in-line with regenerator.

NIST91 Large pulse-tube prototype cooler tested circa 1991 by Ray Radebaugh and others at NIST

5.2 Piston-Displacer

Engines or coolers employing a moving displacer between compression and expansion spaces.

5.2.1 AnnularHX

Hollow displacers, fixed regenerators.

Duplex Combined engine and heat pump, with separate displacers driven by a common piston.

FPSE Displacer-type free-piston stirling engine with displacer arranged co-axially within an annular heat rejector and regenerator assembly and a tubular heater consisting of a number of bent tubes.

FreeCyl Free-casing engine, sometimes called a free-cylinder engine.

TwoStageCooler Two-stage cooler with an annular cold-head arrangement with heat exchangers and regenerators around a stepped thin-shell type displacer.

5.2.2 MovingRegen

Displacers with regenerators inside.

Cassandra Mythical 4 K cooler rejecting heat to a pre-cooled 20 K heat sink.

SplitCycleCooler Free-piston and free-displacer split-cycle cryocooler (pressure-wave generator connected to cold head by a connecting duct).

SplitCycleCooler_RotaryDrive Split-cycle cooler with rotary drive linkages controlling piston and displacer motions:

5.3 Piston-Piston

Engines or coolers where separate pistons drive compression and expansion spaces independently.

AlphaEngine Representative thermodynamic circuit of a double acting stirling engine driven by two simple-crank kinematic linkage components attached to reciprocating pistons.

AlphaEngineFlywheel Similar to AlphaEngine except a flywheel component and two simple-crank kinematic linkage components replace simple-crank kinematic linkages.

6 ThermoAcoustic

Engines or coolers where acoustical resonators, standing waves and feedback circuits perform similar roles to pistons and displacers of stirling cycle machines.

AcousticStirlingSwiftBackhaus Model of an acoustic stirling engine with novel feedback loop built and tested at Los Alamos National Laboratory.

SolarPanPipe Novelty singing-tube, open at both ends with the stack actively heated at one end and cooled at the other by through air flow.

TAdemo Thermoacoustic demonstrator engine built by Greg Swift and associates way back when.

7 Gifford-McMahon

Coolers driven by compressors with low and high pressures alternately connected to a cold head through timed valves. Some samples include the compressor and valves separately. Others combine both into a single pressure-regulated compressor component that just represents the pressure boundary condition seen by the cold head. Which is preferred depends on whether you are designing the compressor and valves along with the cold head or just the cold head.

7.1 BufferTube

GMSingleStage 80 K single-stage GM-style pulse-tube refrigerator driven by a steady mass-flow pump flowing through sinusoidally-varying time-dependent valves and with pressure spikes smoothed by buffer volumes.

GMSingleStageSquareWaveValves A variation of the GMSingleStagen model with sinusoidal valve openings replaced by more abrupt square-wave openings

GM-PTR-SingleStage-DPregulated 50 K GM pulse-tube cryocooler with a pressure regulated compressor component providing the cold-head pressure boundary condition.

GM-PTR-TwoStage-DPregulated 4 K two-stage GM pulse-tube cryocooler with a pressure regulated compressor component providing the cold-head pressure boundary condition

7.2 Displacer

GMSingleStageTimedValvesMovingRegen Traditional moving regenerator/displacer 40 K GM cryocooler with a volumetric-flow compressor and timed valves providing the cold-head pressure boundary condition. Arguably the most realistic of all options for representing the physical elements of the compressor.

8 Joule-Thomson

Coolers implementing a steady-flow throttling process to cool a fluid stream by expanding it from high to low pressure.

6KJTLoop Closed-cycle Joule-Thomson cryocooler operating between temperatures of 15 K and 6K.

LiquefyingJTLoop Steady-state Joule-Thomson helium liquefier where 15 K gaseous helium at atmospheric pressure enters the device, undergoes the Joule-Thomson cooling cycle, and discharges as a steady stream of 4 K liquid helium at atmospheric pressure

9 VaporCompression

Coolers or heat pumps that alternately condense and liquefy a steady-flow fluid stream to absorb or release heat.

RefrigerationLoop Vapor-compression refrigeration cycle, where a high-pressure liquid refrigerant at 40 C at the exit of a condenser heat exchanger expands within a capillary tube to a lower pressure and subsequently vaporizes beginning near 0 C at the entrance of an evaporator to provide cooling.

10 JetEngines

Okay. Not seriously. But still…

turbojet Somewhat whimsical model of a turbojet engine.

turbofan Variant of the turbojet model that adds a bypass fan to approximate a turbofan jet engine

11 ElectroMagnetic

Simple electrical circuits, magnetic circuits, and transducers converting electrical to mechanical energy.

11.1 Circuits

DiodeBridge Diode bridge circuit that rectifies AC voltage to DC voltage.

InductorAirCore Air-core solenoid from first principles.

InductorFerriteCore Ferrite-core solenoid from first principles.

SeriesRLCcircuit Series resistor-inductor-capacitor electrical circuit

SoftFerroB-Hmap DC magnetic flux in a bar of soft ferromagnetic material as a function of applied magnetic potential difference.

Transformer Transformer consisting of two coils wound around a rectangular core.

11.2 LinearActuators

ActuatorTransverseCoil Linear actuator of the type commonly used for hard drive head positioners.

LoudspeakerVoicecoil Voice-coil type linear actuator commonly used for driving loudspeakers.

LoudspeakerVoicecoilAlt Alternative version of the LoudspeakerVoiceCoil employing a right-turned magnetic gap instead of a left-turned magnetic gap.

MotorMovIron Moving iron type linear motor (alternator) consisting of a moving inner iron piece and two fixed outer iron magnetic flux paths.

MotorMovMag Moving magnet type linear motor consisting of a magnet ring moving between inner and outer iron magnetic flux paths.

MotorTransducer Generic linear motor based on a non-physical transducer component that provides mechanical force in proportion to electrical current.

12 RadiationEnclosures

Thermal radiation enclosures.

RadCanEncl Radiation enclosure consisting of a the inner surface of a right circular cylinder exchanging radiation with base and top surfaces

RadCanEnclLong Like RadCanEncl except the cylindrical surface is subdivided into two equal segments each with its own independent temperature in order to better resolve the temperature distribution along the wall.

RadColdFinger Radiation enclosure consisting of a the outer cylindrical and end surfaces of a cold finger exchanging radiation with the inner cylindrical and end surfaces of a radiation shield

RadElectrLead Pair of electrical leads (wires) within a surrounding radiation enclosure.

RadGeneric Example of how to use the generic view configuration component.

RadShieldNested Four closely-spaced concentric spherical surfaces serve as radiation shields to insulate the inner volume from the outside environment.

RadShieldStacked Right circular cylinder of diameter D with spaced radiation shield disks normal to the central axis.

RadSphereEncl Two small spherical surfaces near the center of an outer spherical enclosure.

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