Sage Upgrade History

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A summary of the important Sage software developments over time, as a guide to users thinking of upgrading. Developments for each version are listed by approximate date of implementation (mm-yy format) with the most recent changes listed first. Sage users can display their version number using the Help|About menu command. Upgrades are generally available under an annual maintenance agreement.

Backward File Compatibility

Since version 2, all Sage output files written under any version are readable by subsequent Sage versions although the reverse is not the case. Starting with version 8 there is the limited ability to save a model under a previous version format provided new components introduced after that version are not in the model.

Sage Model Classes

The Sage software includes three main model classes: the stirling-cycle model class, the pulse-tube model class and the low-T cooler model class. In regard to available model components, the stirling model class is a subset of the pulse-tube model class which is a subset of the low-T cooler model class. In the following descriptions, new components not otherwise designated are available in all three model classes. New components in the pulse-tube model class are also available in the low-T cooler model class. New components in the low-T cooler class are only available there.

Version 13

Released as version 13.0 in February 2025

Jan-25 — Interpolated Components

A new descendant of the simple transducer component interpolates the transduction force coefficient $C_f(x)$ (a function of position) from a set of cubic-spline data-pair inputs (x_i, C_{f_i}). A new interpolated spring component does a similar thing for spring force $F(x)$ from data-pair inputs (x_i, F_i).

Dec-24 — Copy-and-Paste

Model component copy and paste tools now support copying from one Sage instance and pasting into another. Previously it only worked by opening the source model to copy, then opening the destination model to paste, without closing the Sage application.

Sept-24 — New Refprop Fluids

Added to the default gas data file: argon, carbon dioxide, methane, propane, isobutane, water. Existing helium, hydrogen and nitrogen are reformulated with improved bubble-line smoothing (below). **Note:** internal energy values are no longer shifted from default Refprop values (negative values now allowed). Existing finicky 4K cooler models might require re-initializing or other solving tricks to converge as a result. To avoid this problem you can choose not to update gas properties from the new gas data file when the model loads.

Sept-24 — Bubble Line

Property discontinuities at the bubble line, where vapor slams into the liquid phase, have plagued Sage convergence since the first *refprop* fluids were introduced in version 8 (2011). Improvements to $P(v)$ isotherm smoothing now allow Sage models to converge better through the bubble line, allowing Sage to model a complete vapor-compression refrigeration cycle using a fluid like isobutane.

August-24 — Solve Status Dialog

Now monitors line-step reductions that prevent solved variables stepping beyond allowed limits. For example temperatures in a 4 K cooler going negative. Identifies the responsible variable and the required step reduction, thereby pointing you toward the part of the model causing convergence difficulty.

July-24 — Duct Turbulence Model

Revised and calibrated to experimental data, now with separate oscillatory and steady-flow branches and less spurious noise for highly non-sinusoidal flows common in GM cryocoolers and such.

July-24 — Grid Plots

For 2D plots a new *animation* feature allows you to scroll through 2D plot curves sequentially — i.e. to plot individual position data curves at successive time nodes or individual time data curves at successive position nodes.

May-24 — SCFusion Model Class

A new stirling-cycle fusion model class succeeds and replaces previous stirling-cycle, pulse-tube and Low-T Cooler model classes which are discontinued as of Sage version 13. The new model class includes all the features of previous model classes and is backward compatible with all previous stl, ptb, and ltc model files.

April-24 — Containers

An issue within Parallel and Multi-Length containers prevented distributed conductors or conductive surfaces of annulus flow paths within composite piston-cylinder components from making y heat-transfer connections with other components of the container. This has been fixed.

March-24 — Sage GUI

The Sage form now groups the EditForm and DisplayForm within its client area instead of spawning them as independent windows, making it easier to locate and manage them.

March-24 — Explore Custom Variables Dialog

The display can now be filtered to show only inputs, outputs, recasts, CAD-tagged or log-tagged variables. New display icons make it easier to distinguish among the different types of customized variables.

Jan-24 — Independent Isothermal Heat Sources

New isothermal-surface and line-heat-source components set temperature according to independent temperature-distribution inputs that can be recast in terms of higher-level user-defined inputs as a means for changing temperature boundary conditions of several lower-level components at once. Previous isothermal heat source components set the temperature according to the non-recastable Tinit temperature distribution inherited from the parent component.

Jan-24 — Soft Ferromagnetic Materials

To minimize glitches in iron-core solenoid inductance as a function of coil current, revised approximate magnetization function to eliminate slope discontinuity.

Dec-23 — Volumetric Compressor

A new component added for modeling positive-displacement compressors of the type used in GM cryocoolers. Specifies inlet volumetric flow rate and clearance volume as inputs, rather than mass flow rate, thereby relating more directly to the specifications of an actual compressor and automatically adjusting mass flow rate as a function of upstream and downstream pressures, like a real compressor.

May-22 — Moving Magnetic Containers

Abandoned magnetic force scaling as a means of conserving energy relative to the energy entering from surrounding poles. Electromagnetic actuator models now converge more reliably at the cost of a small energy leak. Fixed a minor issue with magnetic flux distribution in voice-coil actuators that produced erroneous induction values.

Version 12

Released as v12.2.3 in December 2021

12-21 — Minor Tweaks

The information printed in the solver diagnostic dialog now includes the attempted step value. All plot dialog buttons remain anchored when sizing. Optimizations no longer terminate unexpectedly for no reason with the message "Optimization failed to converge".

11-21 — PV power flows

New built-in variables PVNeg and PVPos calculate average PV power flow rates at the negative and positive inlets of gas domain components.

9-21 — exception handling

Exceptions during optimization now restore the solution to the previous converged state. You can now choose to ignore all out-of-range exceptions in tabular equations of state, effectively allowing extrapolation below the lowest or highest tabulated values for temperature and specific volume. The iterative process in the TofState function is more robust for out-of-range inputs.

7-21 — complex Nusselt numbers

In solid and gas domains that calculate phase-shifted heat transfer and flow friction using correlations derived from simplified linear equations with complex exponential solutions, the formulation has been revised to filter out spurious higher harmonics. This is especially significant in low-temperature cryocooler models with highly non-sinusoidal temperature solutions and low solid heat capacities where heat-transfer higher harmonics without any physical basis could destabilize the solution or produce incorrect results.

6-21 — time-grid heat connections

New time-ring heat-source and heater components allow you to impose time-varying temperature or heat flow boundary conditions on the positive and negative ends of thick-wall, thin-wall or rigorous-surface thermal solids. Such connections impose temperature continuity at each time node, rather than just time-mean temperature continuity, which can be useful if the solid heat capacity is relatively low, allowing large time-varying temperatures.

5-21 — Finding Example Models

A new Help → Example Models menu item makes it easy to find example models distributed with the Sage application. It launches Windows File Explorer, open to the folder where example models and documentation are stored.

4-21 — Low Temperature Regenerators

The solid energy equation for the *quasi-adiabatic surfaces* that represent regenerator matrices now resolves instantaneous changes in specific heat rather than the time-averaged value used previously. This improves accuracy for regenerators operating below 10 K where solid specific heat is both small and highly variable with temperature.

3-21 — Optimization Status Dialog

Now includes a column of *attempted step* values displayed next to optimized values at every iteration. Potentially useful for spotting variables causing slow or erratic optimization progress.

3-21 — CAD variables

User-defined input and output variables can now be marked as CAD variables and written to a tab-delimited text file with the new File → Save CAD variables menu item. CAD variables are separate from logged variables tagged to appear in Optimization and Mapping logs. CAD variables are intended for driving key dimensions of CAD solid models.

2-21 — Fourier series inputs

Coefficients are now entered within cells of a string grid, rather than as individual data pairs. There is a new dialog for entering discrete function values rather than coefficients, and a means to toggle between coefficient and discrete entry formats.

1-21 — Solid data

The list of available thermal-solid materials contains some new materials like 6063 aluminum, nylon, kapton, and common low-temperature regenerator materials Er-Ni, Er3-Co, Er3-Ni, Ho-Cu2, Gd2-O2-S (GOS). Thermal properties for existing material have been updated according to NIST data at cryogenic temperatures. Copy and pasting columns of property data is now supported in the PropBase utility used for translating property data into Sage format.

1-21 — Renaming Model Components

In-line editing capability now supported for model component names displayed in Edit Window.

1-21 — Entering Property Data

Solid or gas properties that vary with temperature like conductivity or specific heat are now entered within cells of a string grid, rather than as individual data pairs. Copy and pasting data from a spreadsheet is now supported.

12-20 — Stick-Slip Dampers

New stick-slip damper components approximate the frictional drag of a sliding object moving over a surface.

09-20 — Grid Plots

Now shown as modeless dialogs so you can view more than one plot at a time and keep the plot windows open while doing other things — e.g. monitoring solved variables during the solution process. A new option adds point markers at grid node values, giving a better indication of actual solved values for time grids. If there is more than one grid in the selected component you can select the one to be plotted from a listbox. Previously only the default grid was available.

08-20 — Diode

A new diode component extends the options for modeling linear alternator electrical loads.

01-17 — Solve Status Dialog

Scroll bars added to view long exception error messages.

01-17 — Explore Custom Variables Dialog

There is now a *View Interpolation* button in the dialog to display the values of cubic-spline or Fourier series recast variables as continuous functions.

11-16 — Generic Cylinders

The gas-to-wall heat transfer formulation now converges more reliable for the case of an isolated volume without gas flow connections (e.g. a simple gas spring model) and more closely approximates the theoretical value.

4-16 — RefpropToSage

Revised pressure smoothing in the two-phase region from exponential smoothing at bubble- and dew-point corners to linear smoothing at dew-point corner. Updated *refprop* gases in GasLTC.dta.

Version 11

Released in January 2016

4-15 — Check Valves

In the pulse-tube model class, check valves now open more reliably and smoothly at the specified opening pressure.

4-15 — Pulse Tube Free Convection and Streaming

In the pulse-tube model class, the free convection loss formulation has been revised to include tilt angle dependence and the suppression effect of high frequency oscillatory flow. The wall-streaming convection loss has also been reformulated and similarly includes a high-frequency suppression effect.

11-14 — Plot Solution Grid

The GUI now supports plotting the computational grid of a model component or connector between components in an interactive dialog. Available as a main menu item or a popup menu item when right-clicking on the component or connector of interest.

11-14 — Solver Diagnostic Dialog Goes Graphical

Non-converging solution variables can now be examined by clicking on points of plots that filter out various types of strange behavior.

10-14 — Improved Listing Functionality

The model listing dialog now includes search functionality, improved text formatting and more control over printed output. Print and save-to-file menu items have been moved from the main Sage form to the listing dialog.

Version 10.1

A minor bug-fix upgrade released September 2014. Fixes the problem of drag rectangles in the edit form failing to disappear after ending the drag process and also a possible endless loop of abort/ignore dialogs when closing the dialog results in re-painting the the display form whose evaluation produced the math exception in the first place.

Version 10

Released in June 2014

6-14 — Submodel Load Problem Fixed

Electromagnet components inserted into submodels loaded from files created before v9 now work correctly. Previously a failure to properly update new submodel variables (Vnorm and Inorm) on load led to access-violation errors.

4-14 — Multi-Select Model Components

You can now select multiple model components in the edit form by holding down the shift key while mouse clicking on them or dragging a selection rectangle over them. You can then move them as a group in the edit form or copy, paste, delete them provided they are not connected to other model components outside the group.

3-14 — Electrically Conductive Magnetic Path

A new component allows you to model eddy current losses induced by a time-varying magnetic flux through an electrically conductive pressure wall.

3-14 — Ideal Transformer

A new electrical component simulates an ideal transformer that steps up voltage and steps down current in an electrical circuit.

3-14 — Power Probe

A new electrical component allows you to measure power flows at any point in an electrical circuit, instead of just power dissipated within the component, as is the case for other electrical components.

3-14 — Bar Conductor

The thermal conduction calculation now considers the variation of thermal conductivity k over the conductor length, $Q = A/L \int k dT$ rather than the previous calculation based on average thermal conductivity, $Q = A/L\,\overline{k}\Delta T$. This gives better accuracy when thermal conductivity varies significantly over the conduction length. The integration is accomplished without a spatial grid using a new integral method available for cubic spline properties.

2-14 — Connector Hints

The connector hint that displays when you hover the mouse over a connector now contains current solution values.

1-14 — Motion Snubbers

Two new components, an absolute and a relative motion snubber, allow you to impose overstroke-preventing end limits to the motion of reciprocating masses representing things like pistons or displacers in stirling coolers.

Version 9.2

A minor bug-fix upgrade released September 2013. Fixes distance-to-pole error for embedded magnets outside pole faces and added FringeMult empirical multiplier for magnetic gap components.

Version 9.1

A minor bug-fix upgrade released March 2013. Fixes a force sign reversal problem in the motion filter components (see below) and improves convergence for moving electromagnetic components.

Version 9

Released in January 2013

12-12 — Improved Exception Tracing

Error messages as a result of math exceptions during variable evaluation (e.g. property interpolation out of temperature range) now include a full description of which variable in which model component triggered the exception.

11-12 — Free Driver

A new component provides a *negative* damping effect so as to simulate a driver that adds, rather than absorbs, mechanical power to whatever it is attached to but does not determine the motion phase. You might use a free driver to model a load, such as a linear alternator, subject to a control voltage or current that specifies the reference phase angle.

11-12 — Explore Custom Variables

The interactive form allowing you to explore user-defined variables in your entire model and trace references among them now includes user-defined inputs and recast inputs too. The previous *Explore User Variables* menu item that opens this form has become *Explore Custom Variables* under a new *Tools* menu, which also includes the *Explore Optimization* menu item

11-12 — Popup Menus

The *Specify* menu items (e.g. specify inputs, . . .) now appear when clicking the right mouse button on the selected model component in the display window or edit window. There is also a menu item for toggling the view of the selected model component from the edit window to the display window and vice-versa.

11-12 — Motion Filters

New components allow you to connect a phasor moving part to a time-ring moving part and vice-versa, essentially filtering out any higher harmonic force components from passing between the two.

11-12 — Recast Variable Out-Of-Range Warning

Inputs pertaining to physical dimensions that must always be positive valued (or at-least not negative) now generate a warning exception when they are recast as dependent variables and their value goes out of range.

10-12 — Electromagnetic Components

All model classes get a large number of new electromagnetic model components ranging from simple electrical components like voltage sources, resistors, inductors and capacitors to magnetic flux components like coils, soft ferromagnetic materials and permanent magnets. Modeling a linear motor or alternator from first principles is now possible in Sage for the first time.

11-11 — Inefficient Adiabatic Compressor

The Low-T Cooler adiabatic compressor component gets a new *efficiency* input for improved realism in modeling compressors and expanders.

10-11 — Listing User-Defined Inputs

The Sage listing now permits filtering built-in and user-defined inputs so they can appear separately.

Version 8

Released in August 2011.

8-11 — Two-Phase Transport Properties

The TBSpline3Gas class (available in Low-T Cooler models) now calculates separate vapor and liquid-phase transport properties (c_p, μ and k) in the two phase region to support future two-phase heat transfer formulations.

8-11 — Gas Mixture Support in RefpropToSage

Low-T Cooler utility RefpropToSage (formerly RefpropToBSpline3Gas) now supports gas mixtures in addition to pure fluids. The utility reads native fluid or mixture files distributed with the NIST REFPROP software and converts the data to tabular equations of state and other properties for use in Sage. The RefpropToSage interface is much more user friendly and includes a graphical display of all tabulated fluid properties for immediate feedback on the conversion process. The tabulation of $P(v)$isotherms across the two-phase region is now smoother and more accurate.

6-11 — Interpolation Overshoot in Tabular Gases

The interpolation method used in tabular gas objects for calculating state and transport properties between discrete data points (v_j, T_k) is now based on *constrained* cubic splines rather than *natural* splines. This greatly reduces or eliminates the tendency to overshoot or undershoot tabulated values at abrupt corners in the data, such as at the liquid bubble point transition where the pressure slope $(dP/dv)_T$ changes abruptly.

4-11 — Save Embedded Properties

It is now possible to save any gas or solid property embedded in your model to an individual data file. This may be useful if your gas.dta or solid.dta property file does not contain that particular property. You can append the saved property file to your gas.dta or solid.dta file where it will then be available in the input selection list for any gas or solid variable of the model.

3-11 — Regional Decimal Separator

Numerical inputs as well as displayed outputs now honor the decimal separator character set under Windows regional settings. Previously Sage would not recognize numerical inputs when the ',' was the regional decimal separator. However, this does not apply to constants entered in algebraic expressions (user-defined variables and such) which still require '.' as the decimal separator character for expression parsing and file portability reasons.

12-10 — SaveAs Previous Version

The menu command "File — Save As" now supports saving your model under a previous stream format, currently only version 7. The resulting output file can be read by the previous version of Sage but any new model component classes or variables added since that version will not be included in the stream.

11-10 — Tagged Variable Listings

The menu command "File — Save Tagged Variables" produces a listing of selected user-defined variables. The header line now appends the parent model name to the variable name so variables with the same name can be identified. Likewise for the headers for these variables that appear in mapping or optimization log files.

Version 7

Released in May 2010.

5-10 — File Associations

The v7 installer now sets Windows file associations so that clicking on a model file (*.stl, etc.) in Windows Explorer will launch the associated Sage application.

5-10 — Pulse-Tube Streaming Convection

The formulation for Rayleigh streaming velocity along pulse-tube walls (compliance tubes) now includes all the terms in the Olson-Swift formulation. Previously some of the smaller terms were ignored.

5-10 — DLL Pop-Up Control

Two new functions SetIgnoreExprError and SetIgnoreRangeError allow you to pre-ignore math errors in user-defined expressions and out-of-range thermophysical property interpolations. Previously you had to manually press the *ignore* button in a pop-up message dialog.

4-10 — Relative Motor Components

Two new linear motor components — a relative phasor motor and relative time-ring motor — apply drive forces between two moving parts instead of between a moving part and ground. They apply a force F to the moving part attached to endpoint coordinate x_{pos} and force $-F$ to the moving part attached to x_{neg}.

3-10 — Solver Maximum Iterations Enforced during DLL Optimizations

Optimizations run under the DLL now return control to the calling program whenever a solution solving process exceeds the maximum number of iterations (MaxTerribIter, MaxTotalIter settings). Previously the optimization process could sometimes run forever in the event the model reached a state where the solver no longer converged.

3-10 — Fixed Heat Flow Sources

New model components Point Heater, Line Heater and Surface Heater allow you to specify heat flow as an input to thermal solids or gas domains and solve the resulting temperature or temperature distribution as an output. They can be used to model electrical resistance heating (cryocooler loads or engine heaters) or other situations where heat flow is a more appropriate boundary condition than temperature.

3-10 — Radiation Exchange Components

The Low-T Cooler model class has new components for modeling thermal radiation exchange between the walls of radiation enclosures and objects inside. There are two types of radiation surface components — one for uniform temperature surfaces and one for distributed temperature surfaces. Several components represent the vrious possible view configurations between the surfaces — the fraction of radiation emitted from one surface reaching the other. You model radiation between two surface components by connecting them to a common view configuration component.

1-10 — Rotary Mechanisms

There is new realism for modeling pistons driven by rotating mechanisms. Typically a new flywheel component connects to one or more new kinematic linkage components (Scotch yoke, simple crank, rhombic drive) which connect to reciprocating masses representing the pistons (or displacers). The resulting reciprocating displacement includes higher harmonics resulting from the kinematic linkage and also fluctuations in the flywheel rotational angular velocity, which is solved as a function of its moment of inertia and the applied torque.

12-09 — More Reliable Value for Grid x-interpolation Option

The initial value (linear or cubic) that appears in the numerical tab of the Model Class | Options dialog is now set directly from the computational grid on load. Previously the initial value was stored in the model initialization file (e.g. *.sin), separate from the model file (e.g. *.stl). That led to a possibly incorrect displayed value when the model initialization file was missing.

12-09 — Improved Error Handling in Parsed Expressions

Error messages displayed as the result of math errors that arise while evaluating user-defined expressions now give additional information about the error. Previously the error message displayed only the user-defined expression itself.

12-09 — Referencable Gas & Solid Properties

You can now reference the properties of the working gas and various solids in user-defined expressions within the GUI or through the DLL interface using function GetRealPart. For example, in the root model level the expression Gas.Rgas returns the gas constant for the working gas. The expression Gas.Cp(ADensity, ATemperature) returns the specific heat C_p as a function of two other user-defined variables ADensity and ATemperature. And so forth. As with other referenced variables, referenced properties are returned in the current dimensional units set in the Model Class | Options dialog. Values for the properties and data tables of gas and solid variables are now also displayed in current dimensional units for consistency. Previously the displayed values were always in SI units.

12-09 — Displayed Significant Figures

The Sage Options dialog now allows you to set the number of significant figures displayed for floating-point numerical outputs. This applies to the display window, the model listing and solution grid dumps. Previously the number of displayed significant figures was 4. New DLL functions SetDisplaySigFigs and GetDisplaySigFigs allow similar control in the DLL environment for the values appearing in listing files.

10-09 — Improved RefPropToBSpline3Gas Utility

The utility program for converting REFPROP fluid property files into Sage tabular gas format now allows you to inspect the T and v data values implied by your choice of configuration constants prior to the conversion process. It also warns you if the choice of configuration constants leads to temperature values that are not strictly increasing. This can happen when the temperatures in the "just above Tcrit" range exceed the maximum temperature supported by the REFPROP property file. This is very unlikely for the usual gases like helium or hydrogen where the max REFPROP temperature is far above Tcrit. But it can happen for high molecular weight fluids.

Version 6

Version 6 is officially finalized in January 2009.

Version 6.0 1-09 — Flow Reversers

The flow reverser components are now available in all model classes. Previously they were just available in the Low-T Cooler model class. Now you can also implement counterflow heat exchangers in the stirling or pulse-tube model classes.

Version 6.0 1-09 — Pdf Sample File Documents

Each sample-model file in the Data directory for the associated model class now has a companion document in Adobe PDF format. Previous documention was in crude ASCII text format and not available for all sample files.

Version 6.0 1-09 — Pdf Help File

The venerable help file Sage.hlp is discontinued in favor of an electronic manual document opened under Adobe Reader. It is the same as the printed manual except with hyperlinked contents, index and internal cross references. All of the navigation features of a standard Windows help file are available along with better typography and formatting. The new electronic manual abandons the proprietary Microsoft help format which required parallel documentation for the help file and the printed manual. Now the electronic and printed manuals are derived from the same source, with different processing to add hyperlink features to one but not the other.

Version 6.0 12-08 — Entropy Calculation

A new derivation for the entropy table in gases employing tabular equations of state improves accuracy at low temperatures and high pressures. This does not affect the solution except for the adiabatic compressor component of the Low-T Cooler model class. Otherwise it only improves the accuracy of output AEdiscr for gas domains.

Version 6.0 10-08 — Line Temperature Drop

A new component provides a framework for including the temperature drop of an external fluid in a stirling-cycle heat exchanger. It is similar to a distributed conductor except imposes a fixed temperature drop between negative and positive y-faces, regardless of heat flux. The idea is that the temperature drop may be recast as a dependent variable based on external heat-transfer analysis implemented in terms of user-defined inputs and variables.

Version 6.0 6-08 — Change Model Bitmaps

The Edit menu now has a "Change Bitmap" item which allows you to change the bitmap images used to represent model components in the edit window. You may load a new image from any bitmap file (*.bmp) that you create using some graphical editing software or have on hand. For example, you might change the default image used for submodels to something representative of what that submodel actually does.

Version 6.0 5-08 — User-Defined Inputs

Along with recastable variables, another new feature allows you to add custom input variables to model components. For example, you may define an input in a submodel, then reference that input in recast inputs of any number of child components. In that way a single input at the submodel level assigns the values of what were previously several independent inputs meaning the same thing. User-defined inputs behave just like built-in inputs for mapping or optimizing purposes.

Version 6.0 5-08 — Recastable Variables

It is now possible to *recast* independent model input variables as dependent variables — to reformulate them so their values are calculated in terms of user-defined expressions involving other model variables. Recast variables allow you to implement geometrical model constraints, or other explicit constraints, as part of the solution process. For example, you may specify that a piston frontal area be calculated as a function of parent cylinder diameter. Previously the only way to implement such constraints was during the optimization process. Using recast variables instead, eliminates explicit constraints and associated variables from an optimization structure, making it easier to understand and run faster. There are advantages for the mapping process too because a single mapped variable can affect other inputs that you have recast as dependents, allowing you to map along a *curve* in model space rather than just along the input *coordinate* directions. Recasting variables is done via a straight-forward dialog that opens under the Specify|Recast Variables or Scan|Recast Variables menu items.

Version 6.0 5-08 — Check Valve Improvement

A problem of "numerical leakage" for for high back pressures has been corrected in the check-valve and time-dependent-valve components of the pulse-tube model class. Previously, a maximum pressure drop limit caused higher than expected mass flow rates when the pressure drop across the valve was too high.

Version 5.8 3-08 — Copying Displayed Text

Display windows now support selecting text and copying to the Window's clipboard for later pasting into document or spreadsheet. Likewise for the listing preview window.

Version 5.6 12-07 — DLL Pop-Up Reduction

Errors during the solving and optimizing processes that previously resulted in pop-up error message are now handled differently. In the usual Sage interface there is not much apparent difference because they generate error messages, much as before. But in the DLL interface the errors are handled silently. The DLL returns control to the calling program without the need for the user to click an OK button in a message dialog.

Version 5.5 12-07 — DLL Solve Process

The DLL now implements a quit-after-effort policy under which the solve process gives up when further effort toward convergence seems hopeless. In this case those functions that implement silent exception handling return Status = 1 and log an error message, giving the calling program the option to deal with the problem.

Version 5.5 12-07 — Evaporator-Condenser

A new component in the low-T cooler model class adds or removes heat from an incoming two-phase flow stream to completely evaporate or condense it without changing its temperature or pressure. Heat is added or removed through a built in heat-flow connection and the temperature of the connection relative to the incoming fluid temperature determines whether the fluid evaporates or condenses.

Version 5.4 11-07 — Sharp-Edged Orifice

The sharp-edged orifice gets a make-over that enables it to handle choked flow (sonic velocity in throat) and generally work like it should for high pressure drops. Mass flow rate as a function of pressure drop is more accurate than before, especially for downstream pressure very small compared to upstream pressure.

Version 5.3 10-07 — Flow Restrictor Improvement

A reformulation permits much higher pressure drops than previously possible for flow restrictors (sharp-edged orifice, sintered-powder plug, etc). Previously the downstream pressure could be no lower than about half the upstream pressure. Now it can be much lower. This is a very useful improvement for flow restrictors used as the orifice in a J-T cooler or time-dependent valve of a GM cooler.

Version 5.2 10-07 — View Interpolation Option

Input dialogs for spline and Fourier-series inputs now include a ”view interpolation” button. Pressing that button displays a plot of what the continuous cubic-spline or periodic time function implied by the data looks like.

Version 5.1 10-07 — Tabular Gas Improvement

The iterative method used to solve specific volume $v(T, P)$ and temperature $T(\rho, \rho e, u)$ now converges more reliably near the boundaries of the two-phase dome leading to fewer exceptions during the solving process.

Version 5.1 10-07 — DLL Visual

New functions make it possible to set and get the caption at the top of the access form.

Version 5.1 10-07 — Solver Dialog Accept Button

A new “Accept” button in the solver progress dialog allows you to terminate the solution process and keep the solved variables at their current state, without restoring them to their entry values. In effect you are telling the solver that convergence is good enough for you and to proceed accordingly. Terminating this way fools Sage into thinking the solution has converged, regardless of what the convergence error actually was at the time of termination.

Version 5.1 10-07 — Solver Exception Handling

If the solve line-step process encounters a software exception (math error, out-of-range interpolation) resulting from taking too-large a step, it halves the step size and tries again. Previously the solver terminated on such exceptions. If it encounters a more serious exception (e.g. the user presses the stop button) the solver terminates as before. But first it restores the solved variables (all implicit variables visible or invisible) to their entry values. The new exception handling applies to all solution processes, whether invoked directly from the GUI or indirectly as part of mapping, optimization or DLL function call and makes the solution more likely to converge for the current solve process and on the next solve attempt. Especially when the solution values are near the limits of the interpolation range for tabular gas or solid properties.

Version 5

Version 5 is officially released in August 2007. The printed manuals are not updated but the electronic manuals SageManual.pdf and StirlingManual.pdf document the changes since version 4.0. The electronic manuals are distributed with the software.

Version 4.6 7-07 — Pressure-Source Connection

Connecting a pressure-source (charge bottle) component to a gas domain now determines the time-average pressure at the negative end of the domain as the visual connection icon suggests. Previously the pressure-source connection determined the space-time average pressure over the entire gas domain. This change only affects gas domains with NCell > 1 having a significant time-average pressure gradient — e.g. steady-flow J-T models under the Low-T Cooler model class.

Version 4.6 7-07 — Comments

All model components now have an optional comment field. You can add comment text under the new Specify|Comment or Scan|Comments menu items. Comments appear at the top of the model-component display window and in the listing.

Version 4.5 7-07 — DLL Dimensional Units

New function SetDefaultDims resets the dimensional units of the model loaded in the access form to default SI units. Afterward the Get/Set ... Real/RealPart functions operate in SI units.

Version 4.5 6-07 — DLL Visual and GetReal Behavior

The solve and optimization status dialogs are now hidden on after the DLL solving or optimization process finishes. New functions make it possible to hide and show the access form. Function GetRealVal and its extended counterpart now work with user-defined variables as well as built-in real-valued variables.

Version 4.5 6-07 — Extended Precision DLL Functions

The DLL now contains extended precision versions of the Get/Set ... Real/RealPart functions for use when greater precision is required. They are named GetExtendedVal, and so forth.

Version 4.3 10-06 — Explore User Variables

If you ever wanted to trace dependencies among the user-defined variables in your model, a new Process|Explore User Variables menu item makes it possible. An interactive form opens up where all user-variables for the entire model are listed together in a tree structure. There is a tool that allows you to trace which variables reference or are-referenced-by other variables. Copy and paste operations are also supported, along with all the usual editing operations.

Version 4.2 9-06 — Connector Hints

The hint that appears when moving the mouse over a connector arrow now contains more information for tracing it from the display level down to its origin. The hint contains the names of all child components along the chain below the current display level.

Version 4.1 9-06 — Solver Exceptions

Recovery from exceptions during the solve process is improved. After taking a step that results in an exeption the step is undone, leaving the solved variables in a valid state. Previously the solution remained in the exceptional state requiring re-initialization or re-starting from a saved solution. The method is not perfect though, as some dependent variables (outputs) that are not evaluated during the solution might still generate exceptions if the solved variables drift too near the limits of their range.

Version 4.1 8-06 — Free Cylinder Components

Two new piston-cylinder composite components are now available, each with two built-in reciprocating masses, one representing the piston and the other the moving cylinder or casing of a so-called "free cylinder" machine. One implements phasor reciprocators and the other time-ring reciprocators. These components were created to more accurately model shuttle heat transfer compared to previous single-moving part composite components. The shuttle heat transfer calculation is based on the relative piston-cylinder motion.

Version 4.1 7-06 — New Functions

Binary functions Amp(x, y) and Arg(x, y) are now available for use in expressions. They return the amplitude and argument (phase) of a complex number (phasor) (x, y). The Arg function returns a value in radians in the the range $[-\pi, \pi]$, which is more informative than the previously available ArcTan(y/x) which always returns a number in the range $[-\pi/2, \pi/2]$

Version 4

Version 4 is officially released in April 2006. The badly outdated printed manuals are brought up to date and now produced in pdf file format. They are included in electronic form on the software distribution CD and paper copies are printed by a digital-press vendor rather than the local photo-copy shop. The stirling, pulse-tube and low-T cooler model classes are combined into a single manual.

4.0 beta 4-06 — DLL Option and Grid Functions

The sage DLLs now have functions for reading and setting Sage options (most of those available in the GUI under Options|Sage and Options|Model Class) and a SaveSolutionGrid function for producing ASCII text files containing the solution grids for a specified model component and its child components.

4.0 beta 3-06 — Random Fiber Correlations

Random fiber correlations are revised once again. Recent heat-transfer and pressure-drop data at porosities as high as 96% is combined with historical data at porosities as low as 69% into master correlations that cover the entire range of porosities.

4.0 beta 2-06 — Conductive Surface Tortuosity

For consistency, the conductive surface component now discounts axial solid conduction by the tortuosity factor when employed as a the solid surface within a matrix type heat exchanger. Previously the tortuosity formulation only applied to quasi-adiabatic surfaces (e.g. rigorous surface), which are typically used for regenerator matrices. Conductive surfaces are used when modeling a heat-exchanger matrix, such as a stack of copper screen, where heat is conducted to the outside along the plane of the screens. Tortuosity only affects solid conduction in the axial flow direction.

4.0 beta 2-06 — Generic Matrix Reformulation

The generic matrix heat-exchanger component now includes a tortuosity formulation of the form $f_s = c_1 + c_2(k_s/k_g)^m f_{Maxwell}$, where $c1, c2, m$ are inputs and $f_{Maxwell}$ is an analytic approximation derived for spheres embedded in a medium of different conductivity. Previously tortuosity was 1.0. The friction factor in the associated gas component now includes an additional term c_3/R_e, with c_3 an input. Previously friction factor had only two terms $f = c_1 + c_2 R_e^m$.

4.0 beta 2-06 — Tortuosity Reformulation

The tortuosity (solid conduction multiplier) for porous matrix solids has a new formulation that considers both solid and gas conductivity and matrix porosity. It is calibrated to NIST test data for packed screen and spherical particle regenerator matrices. Previously Tortuosity was an output variable in matrix-type heat exchanger components (woven screens, packed spheres, etc.). It now appears at a lower level within the wall-surface child-component. User-defined variables and constraints that referenced the old Tortuosity may have to be revised to find it in the new location. The meaning of the Tortuosity output has changed a bit. Under the new formulation tortuosity is is the space-time average, because tortuosity is calculated locally in the solution grid as a function of the local gas and solid conductivities. Previously no averaging was necessary because it was independent of temperature with one value applying to the entire matrix.

3.97 2-06 — Valensi in Matrix Gases

Mean Valensi number (measure of hydraulic diameter as a fraction of viscous penetration depth) is now an output in matrix gas domains. It is not used for any heat-transfer or flow-resistance calculations but it is useful for gaging when those calculations might be invalid because quasi-steady flow assumptions are no longer justified (if $V_a \gg 1$, depending on matrix structure).

3.97 2-06 — Optimization & Mapping Order

It is now possible to change the order in which optimized and mapped variables appear in the selection dialog, which affects how they are displayed. For mapped variables, it also affects the mapping-loop nesting order.

3.97 2-06 — Status Dialogs

The mapping and optimization status dialogs now include a numbered list of mapped or optimized variables and current values, updated each iteration.

3.97 1-06 — Display Window

The Display|Add-Page dialog now permits you to select multiple model components for the display window by pressing the ctrl or shift key during the selection process. Drag-and-drop now works for re-positioning tabs in the display window.

3.97 12-05 — DLL Listings

The sage DLLs now have functions SaveListing and SaveTaggedVars for producing ASCII text files containing the model listing and user-defined variables that are tagged to appear in log files (those that had the "write to log file" checkbox selected during their definition).

3.97 12-05 — Copy-n-Paste Fix

The copy-n-paste enhancement (v 3.95 above) failed when pasting an annulus (shuttle/seal/appendix) child component into a composite piston-cylinder component. The problem is now fixed.

3.97 12-05 — Containers Upgrade Too

The upgrade-on-load feature that enables you to change a stirling (*.stl) file into a pulse-tube (*.ptb) or low-T cooler (*.ltc) file now upgrades container-class subcomponents too (parallel, multi-length and submodel containers). Previously a container from a stirling model, say, would have remained a stirling-class container without including the additional components in its child-creation palette available in a pulse-tube or low-T cooler container. Worse, the copy-and-paste enhancement (3.95 above) failed for such non-upgraded containers because the child-creation pallet of the parent model component does not have a seed of the non-upgraded container class type. With the container upgrading improvement, copy an pasting of containers in upgraded models works as expected.

3.97 12-05 — Submodel Containers

It is now possible to group model components together into submodels, organized within a separate *submodel* container component having its own window. This is handy for organizing large models, multi-stage models, managing display screen clutter and copy/pasting of groups of components simultaneously.

3.97 11-05 — Highlight Mating Connections

In the edit window, clicking on a connector arrow for for a connected model component now highlights both the clicked-on arrow and it's mate. This is useful for tracing connections in large models. Previously it was necessary to manually search for the arrow with the matching number.

3.96 10-05 — DLL

The sage DLLs now support model building, editing, connecting disconnecting, etc., as well as improved access to model variables for getting or setting values.

3.95 9-05 — Copy-n-Paste

The copy-and-paste functions now work for pasting a model component into a different parent component from the one originally copied from — possibly in a *different* model file. This will be a big time saver for users who want to create a new model file by copying components from one or more existing model files. The only restriction is that the paste parent be capable of supporting the copy. In other words, the paste parent must contain a seed in its child-creation palette of the same class type as the component to be pasted. Previously the paste parent was restricted to the original copy parent.

3.93 5-05 — DLL Enhancement

The Sage DLL can now set real parts of constants (like Tinit). It was previously restricted to setting real parts of independent variables.

3.92 4-05 — Multi-Length Heat-Flux Transformer

A new component permits transverse heat-flow connections between different-lenth heat-exchanger components. For example, the walls of a tube spiral-wrapped around a central tube. Available in a new "multi-length container" component.

3.91 3-05 — NTnode = 1

The mininum allowed time-grid node count NTnode is reduced from 4 to 1 to speed up solutions in J-T cooler models or in other models employing time grids for which the desired solution is independent of time.

3.91 3-05 — extended grid dumps

The solution-grid file produced by the Save Solution Grid command is extended to include the entire child-model branch of the active model component, instead of just the active model component. It is now possible to dump all the computational grids of the entire model to a single text file by executing this command for the top-level root model.

3.91 3-05 — tabs appearance

Updated tabs in the edit window, display window and component palette so they do not gray illegibly for no good reason.

3.9 1-05 — nonlinear spring revision

The stiffness formulation $K(x)$ for nonlinear-springs is modified so that it represents the derivative of a force curve dF/dx, rather than an effective value (as in $F = -xK(x)$). The same inputs are used but the restoring force is different.

3.9 11-04 — flow separator

The low-T cooler model class gets a flow-separator component designed to separate two-phase incoming flow into vapor and liquid streams.

3.9 11-04 — utility for generating tabular-state gases

A new utility distributed with the low-T model class converts NIST RefProp fluid property files (*.fld) to the format used in Sage gas database files.

3.9 10-04 — explore optimization

A new menu item lists all optimized variables in a model, grouped by model component, with subject-to constraints listed in a parallel column. This helps to spot over-constrained or infeasible optimization specifications in complicated models.

3.9 10-04 — gas density normalization

Gas domain density normalization is revised so that it scales with the top-level Tnorm input rather than always based on a presumed 300 K temperature. This improves convergence for extremely low temperature models where gas density is relatively high.

3.9 9-04 — more optimizer/mapper control

The Options|Sage dialog gets new edit boxes for setting the number of iterations to wait in a poorly-converging model before reducing step size and increasing maximum total number of iterations.

3.9 9-04 — pressure-regulated compressor

The low-T cooler model class gets a new compressor component where the desired pressure rise is specified as a Fourier-series input and mass flow rate adjusts according to the total system flow resistance.

3.84 8-04 — new tabular equation of state with pressure-dependent transport properties

The low-T cooler model class gets another improvement to the tabular equation of state where data for viscosity and conductivity are now read as input tables $\mu(v, T)$ and $k(v, T)$. Now transport properties are a function of local temperature and pressure, instead of just temperature. This is useful for modeling G-M or J-T coolers where pressures are dramatically different in different parts of the same model.

3.83 8-04 — grid initialization on structural change

When grid structural inputs NTnode and NCell are changed the new grid is now initialized by interpolating between solved values of the previous grid, instead of from default values. Solution convergence is now much faster and more reliable after such a change.

3.82 8-04 — thermal conduction across gas domains

Gas domains now support thermal conduction continuity across flow connectors according to the value of a new input KmultBnd (0 blocks conduction and 1 allows it). Previously all energy transport was solely by enthalpy flow.

3.82 8-04 — higher-order spatial interpolation in grids

The Options|Model Class dialog box now includes a "Numerical" tab with a check-box for setting the spatial-interpolation accuracy used in computational grids to either linear or cubic. Previously only linear interpolation was available. Sage uses spatial interpolation in its staggered-grid solution scheme for alternate grid locations where variables are not directly subject to the governing finite-difference equation. For components with nonlinear temperature profiles (pulse tubes, sometimes regenerators) cubic may be more accurate although it may not converge as well. The choice of linear or cubic is saved in the initialization file associated with your model file (*.sin, *.pin, *.lin). If you open a model file without the presence of its initialization file, Sage will resort to the default linear interpolation. So, as of this version, if you ever share a model file with anyone be sure to also share its initialization file so they will get the same solution.

3.81 7-04 — DLL

Sage is packaged in the form of a dynamic link library (DLL) that provides a dynamic interface whereby another program running under Windows can dynamically access Sage functionality to open existing model files, modify inputs and read outputs. Built-in logic ensures that the Sage solution is always up to date when reading outputs. The plan is that Sage DLL's for the various model classes will be compiled on a case-by-case basis and sold as accessories separate from the usual Windows interface. The functionality within the DLL will evolve depending on customer demand.

3.81 5-04 — flow reversers

The low-T model class gets flow reverser components designed to connect to two positive-end or negative-end flow-connectors in order to reverse the flow direction.

3.8 5-04 — append property files

The property database manager (propbase.exe) gets the ability to append data from one file to the end of another. This streamlines management of custom gas and solid property data.

3.8 5-04 — compressor

The low-T cooler model class gets an adiabatic compressor component intended for driving gas flows through J-T cooling systems. Mass flow rate is specified as an input Fourier series.

3.7 2-04 — new low-T model class

Sage gets a new low-T cooler model class designed for modeling at temperatures at or below the working gas critical temperature. This model class incorporates the improved tabular equation of state (*see above* version 3.2 1-02) and future improvements to come. It is possible to open both stirling and pulse-tube model input files under the low-T cooler model class (*.ltc).

3.7 1-04 — read ancestor root class

Model classes get the ability to read input files produced by an ancestor model class. It is now possible to open stirling-cycle input files (*.stl) under the pulse-tube model class (*.ptb).

3.6 7-03 — random-fiber correlations

The correlations for friction factor and heat transfer in random-fiber regenerator matrices are revised again based on more accurate measurements of test-sample fiber diameters.

3.5 5-03 — duct turbulence transition

The turbulence-model decay coefficients for gas ducts are revised to improve modeling of inertance tubes.

3.4 2-03 — random-fiber correlations

The correlations for friction factor and heat transfer in random-fiber regenerator matrices (nearly round fibers in cross flow) are revised to reflect test data at 90% porosity.

3.4 2-03 — appendix model

A conductive-surface is added the list of wall options available for displacer appendix gaps (annulus subcomponent within composite piston-cylinder components). Previously the floating-wall option often produced unrealistic temperature profiles. The conductive-surface option improves the temperature profile and also models axial thermal conduction in the walls, superseding the use of bar conductors for that purpose.

3.4 1-03 — packed-sphere correlations

The correlations for friction factor and heat transfer in packed-sphere regenerator matrices are revised based on test data. This corrects previous overly pessimistic predictions attributed to double accounting for axial thermal dispersion in both Nusselt number (N_u) and enhanced conductivity (N_k) formulations.

3.3 1-02 — thermal connections to regenerator matrix

Transverse thermal connections are now available within the rigorous-surface component used to model the solid part of regenerator matrices. This allows the user to model heat transfer between the regenerator matrix and its canister although the connection passes only the DC component of heat flow and all matrix temperatures in a given transverse slice are lumped together into a single temperature. The effective conduction length is an input.

3.3 1-02 — parallel container

A parallel-container component allows tubular or other heat-exchanger components created within to exchange transverse (G_x) heat flows with each other as required when modeling heat exchangers involving two or more fluid streams.

3.2 1-02 — tabular gas improvement

The first of many improvements to the tabular equation of state which will eventually wind up in the low-T cooler model class. Interpolation values for the internal energy formulation $\varepsilon(v, T)$ are now read as inputs to increase smoothness and improve convergence stability. In the original tabular equation of state the internal energy table was derived from the compressibility table.

3.1 2-01 — time-dependent valve

The pulse-tube model class gets a time-dependent valve intended for modeling the rotary valve of GM type cryocoolers.

3.1 9-00 — optimizer tweaks

Normalization scale factors are added to optimized variables, constraints and objective function as a means to scale step sizes taken during optimizations, preventing over-stepping and under-stepping.

3.1 9-00 — duct friction factors

The laminar friction-factor formulation in ducts is revised to a complex-valued (thermoacoustic) form.

3.1 1-00 — interpolation operator

User-defined expression can now reference spline and Fourier-series variables interpolated at some point (e.g. Tinit(0.5)).

Version 3

Version 3 sees some incremental improvements in existing model classes and the creation of a new model class designed for modeling low-temperature cryocoolers.

3.0 12-99 — solution grids

The File|Save Solution Grid command now adds grids associated with connectors to the listing (flow connectors of gas domains, etc.).

3.0 12-99 — shuttle formulation

The shuttle heat-transfer formula gets a thin-wall correction to improve accuracy.

2.95 10-99 — pulse-tube streaming

The pulse-tube streaming calculation is revised to avoid absurd values for large pulse tubes.

2.95 9-99 — setpoint DC flows

Pulse-tube model class DC flow blocking flow-restrictors get a setpoint DC flow (possibly non-zero) specified as input DCRhoUA. Previously, DC flow blocking restrictors produced exactly zero time-average mass flow rate.

2.95 9-99 — interface improvements

Sage now checks for circular references when parsing user-defined expressions and allows the user to save the solution grid, tagged variables and listing during solution processing.

2.95 9-99 — flow restrictor initial temperatures

In the pulse-tube model class, flow restrictors now have an initial temperature input Tinit which can be adjusted to improve convergence from initial conditions.

2.95 9-99 — endpoint pressure outputs

Gas domain Fourier-series pressure outputs, previously available only as a spatial average, are now available at both endpoints.

2.95 9-99 — mass flow driver

The pulse-tube model class gets a *mass flow driver* which imposes phasor mass flow rates on gas domains without affecting the mean flow or higher harmonics.

2.94 8-99 — improved accuracy under NT

Recompiling under Delphi 4 fixes a problem with reduced solution precision when running under Windows NT.

2.93 7-99 — show window command

A new menu command allows users to bring display or edit windows to the front.

2.93 7-99 — tagged variables

Users can now print a list of tagged user-defined variables to a special file using the file|Save Tagged Variables menu item.

2.93 7-99 — cylinder heat transfer

Cylinder-gas Nusselt number is revised for smoother (first-derivative continuous) transition to turbulence in order to improve convergence stability.

2.92 6-99 — expression functions

Previously users could only use simple arithmetic operators in user-defined expressions. Now users can also invoke several built in functions such as abs, sqrt, cos, and so forth.

2.91 4-99 — mapper and optimizer step logic

Previously, large steps during mapping or optimization were liable to throw the solution into an unsolvable state from which there was no recovery. Now steps are taken more tentatively and abandoned and re-tried with a reduced step if the solution shows signs of non-convergence. These step reductions are displayed in the status dialogs that pop up when running mappings or optimizations. Optimizations now converge more reliably than they did before.

2.9 3-99 — relative springs and dampers

Sage gets *relative* spring and damper components designed for providing forces between two moving parts instead of just between a single moving part and fixed reference.

2.8 1-99 — combustion space

Variable-volume spaces get a new *combustion gas* component supporting direct gas heating through input FQcombust.

2.8 12-98 — tapered compliance tube

A new descendent of the compliance tube component allows users to specify diameter as a function of position. In addition to being useful for modeling *pulse tubes*, it is useful for modeling tapered resonators, transition sections, etc.

2.7 10-98 — stabilizing gas domains

Gas domains get a numerical stability input UpwindFrac which helps to stabilize the solution in some cases.

2.6 5-98 — streaming revisions

In the pulse-tube model class the formulation for streaming wall-velocity in compliance ducts (pulse tubes) is modified for variable cross-sectional area and the formulation for the streaming convection loss is modified to behave better in the high velocity limit.

2.6 4-98 — tabular equation of state

Sage gets its first version of a tabular equation of state for helium that improves modeling accuracy at very low temperatures, compared to the previous ideal or Redlich-Kwong equations. Transport properties (conductivity and viscosity) remain tabulated as functions of temperature only, requiring separate formulations for various ranges of pressure. Because of the way gas internal energy tables are generated, solution convergence is poor near or below the critical temperature.

2.5 3-98 — check valves

The family of flow restrictors in the pulse-tube model class gets a check valve which allows users to model a reasonable approximation of a one-way valve, although resolution is somewhat of a problem due to the coarse time grids typically used in Sage models.

2.5 2-98 — interpolation detail

The property database software gets a new feature enabling the user to generate any number of property values between cubic-spline interpolation points as a way to gage interpolation accuracy.

2.5 2-98 — spline error

An error is fixed in the cubic-spline interpolation method that had resulted in incorrect interpolation for property data using large numbers of interpolation points.

2.4 12-97 — generic cylinder bug

A bug is fixed in generic cylinders that had been corrupting hydraulic diameter and related calculations.

2.4 12-97 — mass flow pump

The pulse-tube model class gets a *mass flow pump* which provides a mass flow rate boundary condition (arbitrary Fourier series) to gas domains without the need for mechanical pistons.

2.3 11-97 — full-harmonic time differencing

It used to be that time derivatives calculated within time grids were accurate only for the first harmonic. Higher harmonics suffered from numerical errors increasing with the order of the harmonic. Now all resolvable harmonics are time-differenced exactly.

2.3 11-97 — linear motors

Two linear-motor components, one a phasor version and the other a timering version, now make it possible to drive reciprocating masses with forces proportional to electrical current inputs, although the physics is extremely rudimentary.

2.3 11-97 — nonlinear springs

A nonlinear spring supplements the existing linear spring component. It produces a spring rate that varies quadratically with extension.

2.3 10-97 — fix close procedure

The file|close menu command now closes Sage normally rather than producing abnormal termination.

2.2 10-97 — 32 bit version

Recompiling under Delphi 3 produced a "32 bit" version taking full advantage of Intel 32 bit architecture and new MS Windows operating systems. Sage runs twice as fast with improved precision.

2.1 6-97 — detect property database upgrades

A named variable like aluminum representing an itemized choice for a solid or gas substance might have its defining data changed in a Sage property database file with the value stored in a model input file remaining unaffected. A new feature compares, on file opening, the defining data for all named inputs with values in the current property database. If Sage detects a discrepancy a warning dialog pops up allowing the user to update the defining data automatically.

Version 2

Version 2.0 is released in June 1997. In version 2 Sage evolves from a 16 bit program running under Windows 3.1 to a 32 bit program running under Windows 95, 98, . . . and NT. Several minor problems with the user interface disappeared and several new features appear. In the stirling model class some model class components evolve and a few new components come into being. The pulse tube model class receives many new components. While some of these are intended for pulse-tube refrigerator modeling, others come about to address needs in modeling acoustic circuits of thermoacoustic devices.

Versions 0 and 1

Sage development begins in January 1993 with some preliminary ideas for object-oriented modeling for engineering applications. At that time the internal name of the software project is Optima. In June 1996 the software is developed and tested to the point where it is released to the general public as Sage version 1.0. In the next year subsequent versions (1.1, . . .) are released but the details are not documented here because all known version 1 users have long since upgraded.