SuperSteam User Manual, Version 1.0

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Engineering Services & Software

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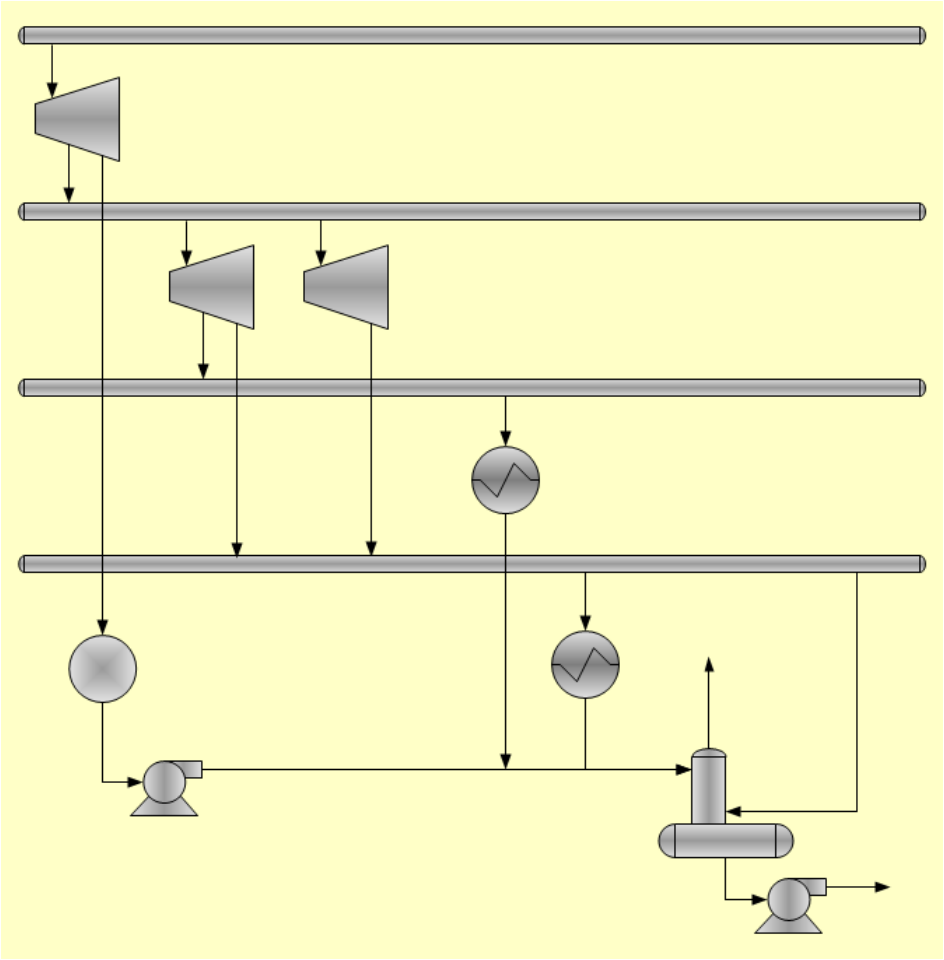

SuperSteam User Manual

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SuperSteam 1.0 User's Guide

Introduction

SuperSteam utilizes sophisticated numerical methods to quickly solve an overall steam balance for a chemical facility or a power plant. It allows any number of headers, turbines and heat exchangers/users. It uses the steam properties of NIST 1997. It has a very user friendly input and clear output. It is referred to hereafter as SS 1.0

Program Input via the Tabular form

This section describes the required and optional user input. Please examine the main input form carefully. There are five tables titled Headers, Boilers, Turbines, Head Exchangers and Surface Condensers. Except for the Surface Condensers table, each table has a "Add/Edit" button right below the heading. The Surface condenser table has an "Edit" and "Delete" button.

If a table is empty, clicking the Add/Edit will open a form which corresponds to that item of that table. The form will be free of entries and is for adding a new item. If the table is not empty but no lines in the table are selected, then the clicking the Add/Edit button will still open a form for a new entry.

If a line in the table is selected, then clicking Add/Edit (or double clicking the selected line) will open the form not to add a new item but to edit the existing entries.

To delete an item, select it, then right click and select "Delete Selected Item" from the context menu.

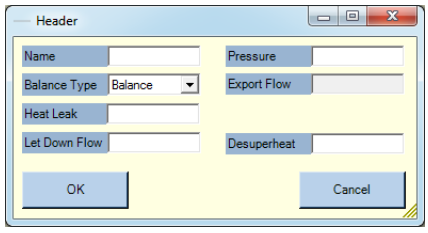
The following is a detailed description of all required and optional entries.

Title & Case

SS 1.0 allows for the entry of one Title and one Case. These entries are optional but their use is encouraged as a reference. They appear in the report and are saved with the input, thus making it easier to identify the project and case for which the input file was created.

Headers

The first thing that should be entered is the Headers because the input for all other operations (turbines, heat exchangers, boilers) requires references to the Headers so have your headers data ready and enter all the headers first.



The input form for a header is quite simple. The first two entries are the Name and the pressure. The name is more like a tag (e.g. HHP for High High Pressure), no spaces are allowed. The pressure is the pressure of the header; it is fixed and does not change.

The next entry is Balance Type: Import, Export, or Balance.

Select Import if the header receives steam from a boiler whether the boiler steam production will be specified or if SS 1.0 is to solve for it.

Export is up to the user. You may desire to export a certain quantity of steam for use elsewhere. If that is the case, then select Export and specify the flow rate in the export flow box. Note that this box will only be enabled if the balance type is Export. If the export flow is unknown, then leave the flow rate box blank.

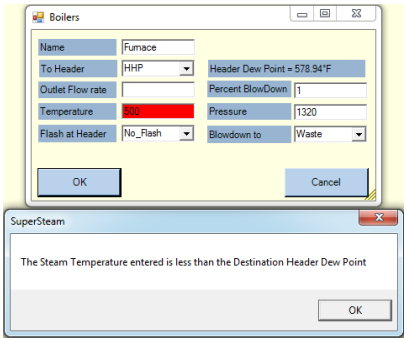
If you are not sure if the steam inlet is in excess (or short), then specify “Balance”. A header balance type of “Balance” means that the Header is balanced; all inlets will equal all outlets. However, if SS 1.0 determines that there is excess steam then it will calculate the export needed from that header.

The next entry is the Heat Leak. Please be careful applying heat leaks. We recommend solving the problem first with 0 heat leaks first, make sure all header temperatures are above the dew point then apply the heat leak and make sure that all header temperatures remain above the dew point

The next entry is let down flowrate from the current header to the next lower header. If you wish to desuperheat a letdown, then specify the desuperheat temperature. Desuperheating will be made using boiler feed water.

Boilers

Boilers supply steam to headers but only one boiler is allowed per header. The input for boilers is also quite simple.



Enter the name of the boiler (this is more like a tag, than a name, e.g. B-101) and spaces are not allowed.

The next Entry is “To Header”. All the headers you already entered will appear in this combo box. Select the header which the boiler supplies steam to.

Note that once you select the Header, SS 1.0 will calculate and display the dew point temperature for that header. If the steam production from this boiler is known, then enter this flowrate in the Outlet Flowrate box. If SS 1.0 is to solve for this flowrate, then leave it blank, but remember, you can only have one unknown.

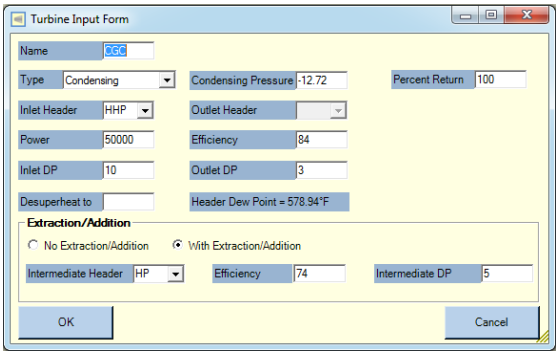
The next entry is the blowdown from the boiler, usually 1% or so but depends on the quality of the BFW. The blowdown is considered a loss and is part of the calculation for the water makeup flowrate.

The next two entries are the temperature and pressure of the produced steam. Make sure that the pressure is higher than the pressure of the header it supplies steam to and the temperature is higher than the dew point temperature at the pressure of the header. If you specify a temperature lower than the header dew point temperature, SS 1.0 will displace and error as shown in the figure above.

Instead of wasting all of the blowdown, you have the option to drop the pressure of the blowdown to a pressure matching that of the header and feed the flash vapor to that header. This is the combo box named “Flash at Header”. All the headers you already entered will appear in that combo box. If you do not wish to flash the blowdown then select “No Flash”.

The next box “Blowdown to” has two options. You may take the blowdown to waste where it is no longer involved in this system or you may take it as feed to the deaerator. If the blowdown was flashed, then only the remaining liquid will go to waste or to the deaerator. The option of taking feeding the blowdown to the deaerator might be deleted in the future, so if you need this option, please give us feedback.

Turbines



Turbines are usually the primary users of steam. Turbines come in various configurations, some are one-stage (non-extracting) others are two-stage turbines which allow extraction or addition of steam at the outlet of the first stage. Some turbines expand the steam to another steam header, these are called “Back-Pressure” while others expand all the way to sub-atmospheric pressure usually between 3.5 to 4 mmHg (1.7190 psia to 1.9646 psia). These are called condensing turbines. SS 1.0 allows all the above configurations and combinations thereof.

Enter the name of the turbine (this is more like a tag, than a name, e.g. T-501 or CGC). Spaces are not allowed.

The next line starts with the turbine Type. Select Condensing or Back Pressure. If you select Back Pressure, then the boxes labeled Condensing Pressure and Percent Return will be disabled. These entries are not valid for a back pressure turbine.

If you select a Condensing turbine, then you have to enter the condensing pressure and the Percent Return. The Percent Return is the percentage of the condensate which will return to the deaerator. If you enter 100%, then all of the condensate will enter the deaerator. If you enter say 95%, then only 95% of the condensate will enter the deaerator, the rest will be considered a loss and will be accounted for in the calculation of the Water Makeup Flowrate.

On the next line, select the Inlet Header from the drop down list. If you selected a condensing turbine, then the next entry, Outlet Header will be disables but if you selected a Back Pressure turbine, then you need to enter the Outlet Header. Note that once you select the Inlet Header, SS 1.0 will calculate and displace the dew point temperature for that header.

The next entry is the turbine power. Whether the turbine is a one-stage or two-stage turbine, this is the total power of the turbine. The next entry is the Efficiency. This one is different. If the turbine is a

single-stage turbine then this is the efficiency of the turbine but if it is a two-stage turbine then this is the efficiency of the first stage.

Inlet DP is the pressure drop from the header to the inlet of the turbine while outlet DP is the pressure from the turbine outlet to the destination header.

You have the option to desuperheat the inlet of the turbine to a temperature you specify. This can be entered in the box "Desuperheat to". The header dew point temperature is displayed next to that box. If you wish to desuperheat the turbine inlet, make sure you enter a temperature above the header dew point temperature.

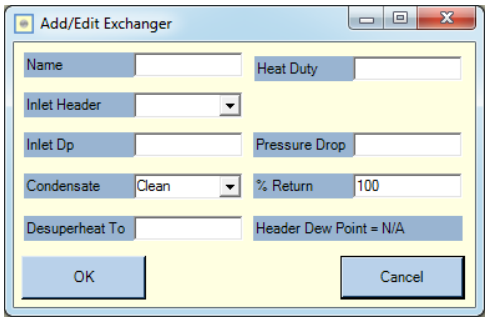
Whether the turbine is Condensing or Back Pressure SS 1.0 allows the option to have Extraction/addition. If that is the case then click the radio button "With Extraction/Addition", select the Intermediate Header. Note that a Turbine with Extraction/addition is a two stage turbine. The adiabatic efficiency you entered above is for the first stage. Enter the adiabatic efficiency for the second stage.

Intermediate DP is the pressure drop from the outlet of the first stage to the Intermediate Header.

Once you made all the entries, click OK and your turbine will be added to the table in the main form. If you change your mind, click Cancel and your entries will be discarded.

Heat Exchangers

Heat exchangers in SS 1.0 can be used to model steam users that are heat exchangers such as distillation column reboilers, regeneration gas heaters, etc.



The input form starts with the Name. Again, this is more like a tag than a name (e.g. E-101) and spaces are not allowed.

Heat Duty is the amount of heat that needs to be supplied to the exchanger.

Inlet Header. Select the Header supplying steam to the heat exchanger. Note that once you make your selection, SS 1.0 will calculate and display the dew point temperature of the selected header.

Inlet DP is the pressure drop from the header to the inlet of the heat exchanger.

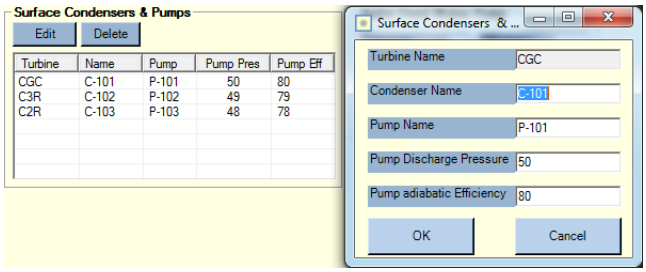
Pressure Drop is the pressure drop across the heat exchanger itself.

Specify the condensate type (Clean, Suspect or Fouled). A fouled condensate does not go anywhere, it is out of the system and is considered a loss in the calculation of the Water Makeup flow rate.

%Return: Is the percentage of the condensate which returns to the deaerator. At this point, there is no difference between Clean and Suspect condensate.

Desuperheat to: Is the temperature to which you would like to desuperheat the inlet to the heat exchanger. If specified, SS 1.0 will calculate the necessary water injection rate to desuperheat the inlet to the specified temperature. The desuperheating is done using boiler feed water.

Surface Condensers and Pumps



Note that you do not add the surface condenser yourself. Whenever you add a condensing turbine, SS 1.0 will make an entry in the Surface Condensers & Pumps table in the main input form. The entry is simply the name of the condensing turbine you just added. You will have to edit this table to complete the entries. Double click on any line in this table and SS 1.0 will open a form for you to complete the entries.

The first entry is the name of the condensing turbine for which this surface condenser belongs. This entry is fixed and you cannot change it. The next entries are the name of the surface condenser, the name of the pump, the pump discharge pressure and adiabatic efficiency. Note that this figure shows the form for the surface condenser right next to the table with contains the surface condensers. In this case, a condensing turbine named CGC was added. The form pops up when the line containing CGC is double clicked.

Boiler Feed Water Pump

Due to the very few entries, there is no popup form for the Boiler Feed Water Pump.

Specify the Boiler feed water pump discharge pressure and adiabatic efficiency.

Select the driver of the pump using the radio button. If you chose electric, the pump will have no effect of the steam balance. If you choose Steam Turbine Driven then select the turbine from the drop down box. If you have not entered a turbine for this pump, then go ahead and do so. The entry you make for power in the steam turbine form is not relevant but it is best if you enter zero.

Deaerator

The Deaerator is where steam is used to strip the condensate of any light material which may have leaked into the steam system. The % Vapor is the percent of the boiler feed water inlet that is vaporized. Steam Source is the header which supplies the stripping steam.

SS 1.0 considers the makeup water as part of the deaerator. Enter the water makeup temperature and pressure in the designated boxes.

Input via Visio

SS 1.0 has a graphical user interface with Microsoft Visio. Simply launch Visio, close all Stencil and open the stencil that comes with SS 1.0. It is called Steamv2. You can find it in the samples folder.

The stencil comes with all the needed operations. Simply drag and drop the operations from the stencil onto your drawing. Do not use the standard connector of Visio. The Stencil has a connecter, please use the one in the stencil.

Every shape/operation has what Visio calls the shape data. It is a window which appears on the top right corner. If you click and operation and do not see the shape data, View/Task Pans and select "Shape Data"

The Shape Data for every operation is virtually the same as the data required in the input forms described above.

Once you are done drawing and entering the data in Visio, launch SS 1.0 and click the "Read From Visio".

Adjusting & Correcting Input

It is virtually impossible for any of us to set up a steam balance correctly the first time. Even if we did, as projects move from early proposal stages to firm design, simulations are rerun and heat duties and compressors horse power requirements change. Even after that, steam turbine and pump vendors might provide efficiencies different from what you originally assumed. In this section, we discuss making changed to entries, adding and deleting items.

The main input form contains five main tables, Headers, Boilers, Turbines, Exchangers and Surface condensers (are their associated pumps).

To change an entry in Headers, Boilers, Turbines, Exchanger or Surface condensers simply double click the line and SS 1.0 will open the same entry form but will fill it with the values previously entered. Correct the entries and click OK.

You may delete users and turbines anytime just click the line containing the item then click delete.

However, be careful deleting headers since they may have turbines or heat exchangers attached to them. It is recommended that you delete the attachments before deleting the header.

The Number of Unknowns

When setting up steam balances, you are solving for an unknown; usually a required flow rate from a boiler (an import) or maybe an export from a header. You have to have one unknown which the program solves for. Sometimes, depending on the configuration, you can have two unknowns. This is explained as follows:

- The number of extracting turbines is equal to the number of Headers minus one.

States simply, if you have four headers and three extracting turbines them you have to have one and only one unknown. If you have one boiler, thus one import and you do not have any exports from headers, then you should NOT specify the flow rate of the steam production from the boiler. This will be your unknown which SS 1.0 will solve for. If you have an export then that flow rate must be specified. The reverse is true. If you do not specify the export flow rate then you have to specify the steam production/import rate in the Boiler section.

If you have two boilers, thus two imports and you do not have any exports from headers, then you should specify one and only one flow rate of the steam production from one of the boilers. SS 1.0 will solve for the unspecified one. If you have any exports, then they will have to be specified.

If you have two boilers and you specify both steam production rates, then you have to have one export with an unknown flow rate.

- You might run into a case where the number of extracting turbines is equal to the number of headers minus two. In other words, four headers and only two extracting turbines. Mathematically speaking, this problem actually has two unknowns, but if you only have one, SS 1.0 will still solve this problem. It will change the mode of the highest pressure header in Balance mode to an Export mode with an unknown Export flow. But you can do that yourself if you prefer, thus you have two unknowns, one boiler flow rate (import) and one export.
  The situation you want to avoid is having two unknown where both unknowns are flow rates from boilers.

Program output – Results Tab

There is a tab on the main form titled “Results”. It contains the results in tabular form. The following is a description of the content. Note that the titles of each section are in **bold**.

Header Results

The first section is the headers. The headers are tabulated from left to right followed by rows containing the Name of the header, the pressure, temperature, dew point temperature and enthalpy. Make sure that all temperatures are above the dew point. If there is a header at a temperature equal to the dew point then the steam inlet to a higher pressure header is not superheated enough.

The next four rows contain the balance type (Balance, Import and Export), Import temperature, Import Pressure and Import/export flow rate. Remember that if a header is exporting, then the export temperature and pressure are the same as the temperature and pressure of the header.

Boiler Results

The boilers are also tabulated from left to right followed by rows containing the Name of the boiler, the steam production rate, Destination header, steam temperature, pressure, enthalpy, the user supplied percent blow down and the blow down flow rate corresponding to the percent blow down.

If the blow down is being flashed at a header, then the next line contains the name of the header where the flash is taking place followed by the vapor fraction of that flash, the vapor flow rate from that flash, the remaining liquid and the final liquid blowdown destination.

Turbine Results

The turbines are also tabulated from left to right followed by rows containing the Name of the turbine, turbine type (Condensing or back pressure), total power, first stage power, inlet header name, inlet pressure, inlet temperature, inlet flow rate and inlet enthalpy.

Whether the turbine is single or two-stage (with or without extraction), the next set of results correspond to the final outlet (lowest pressure). These results contain the outlet header name, outlet pressure, outlet temperatures, outlet vapor fraction, outlet flow rate, outlet volumetric flow rate and outlet enthalpy.

The next row "Extraction" indicates with a Yes or No if the turbine is extracting or not. If the turbine is extracting, the next few rows show the results for the intermediate stage.

These results are the extraction header, second stage horse power, extraction temperature, extraction vapor fraction, extraction flow rate, extraction volumetric flow rate and extraction enthalpy. If there is water injection for desuperheating then the next line contains the desuperheating water flow rate.

Exchanger Results

The heat exchanger results are also tabulated from left to right followed by rows containing the name of the exchanger, the inlet header, inlet pressure drop, inlet pressure, heat duty, flow rate, inlet pressure, inlet temperature, inlet enthalpy, outlet pressure, outlet temperature, outlet enthalpy and the % return to the deaerator.

The condensate from the heat exchangers is flashed at the pressure of the deaerator. The next two lines contain the vapor fraction and vapor flow rate resulting from the flash.

The next line contains the desuperheating flow rate is desuperheating is specified.

Sometimes, the steam it taken from the header directly to the user where it condenses at the pressure of the header minus the pressure drop. But sometimes, there is a valve at the inlet of the user which drops the pressure significantly. In this case increase the pressure drop at the exchanger inlet to accommodate for the valve. Note that since the enthalpy of the inlet stream is the same, the inlet pressure drop has no impact on the flow rate and a minor impact on the inlet temperature, but it has an impact on the outlet temperature.

Surface Condenser Results

The surface condenser results are also tabulated from left to right followed by rows containing the name of the surface condenser, the turbine which the surface condenser is associated with. The next four lines are heat duty, pressure, temperature and flow rate. The next four lines contains the name of the pup

which follows the surface condenser, the pump discharge pressure, the efficiency of the pump and the pump power.

Deaerator Results

The deaerator results consist of the deaerator pressure, temperature, the header supplying the steam, the steam flow rate, percent vapor, outlet liquid flow rate, and outlet vapor flow rate and the makeup water flow rate.

BFW Water Results

The boiler feed water results start with the driver type; electric vs turbine driven. If turbine driven, then the output will include the name of the turbine associated with the pump.

The rest the results are the pump power, efficiency, inlet pressure, inlet temperature, inlet flow rate, discharge pressure, discharge temperature, inlet and outlet enthalpy.

Since SS 1.0 is still a Beta version, the next line contains a recalculation of the pump power using the inlet and outlet enthalpies and the flow rate just as a check.

Program output – The MS Report

There is a tab on the main form titled “MS Report”. It contains the results in tabular form, but it is designed for printing and final documentation as it contains a header block containing the title, case, date, and page number. Being a header, it is printed on every page.