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LIBPF™

User Manual



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This document is the user's manual for LIBPF[™] models version 1.0; it addresses users who want to interact via graphical interfaces with models developed by others (model user).

Prerequisites:

- Basic knowledge of the operating system and a spreadsheet (Microsoft Excel, OpenOffice / LibreOffice Calc);
- Installed, activated and running LIBPF[™] application.

For more information see:

- LIBPF_USR_installation for the install and removal procedures;
- LIBPF_USR_activation for the rationale and the functioning of the activation system.

Introduction

The LIBPF[™] (C++ LIBrary for Process Flowsheeting) technology allows you to create an executable and interactive form of the model of a process in various configurations, which then can be deployed as a stand-alone application.

The interaction with the model takes place in a controlled fashion through the LIBPF[™] user interface (UIPF: User Interface for Process Flowsheeting). The interface doesn't allow the user to modify the configuration of the process: the present streams and units, their connections and their configurations are fixed once and for all by the developer of the model. An exception can be some specially crafted models that allow the user to tun on and off certain plant units. The interface allows instead to:

- Set the operating parameters and conditions and change the options made available by the developer of the model.
- Perform simulations and sensitivity analyses;
- Save, restore and cancel the cases studied in various conditions;
- Interactively examine the results for streams and units;
- Export the results for all the streams to spreadsheets with Microsoft Excel or OpenDocument ODF formats;
- Export all inputs and results in text or XHTML format.



The LIBPF[™] user interface is compatible with several operating systems: Microsoft Windows (Windows Vista / 7 / 8.1 / 10 Technical Preview), Apple OSX (version 10.8 or later) and Linux (e.g. Debian 7, Ubuntu 13 or later); most of the images shown in this manual have been taken on Microsoft Windows Windows 7, but the appearance of the application and its operation does not change on other operating systems.

The LIBPF™ user interface is an internationalized application that supports 12 languages: العربيـة (Modern Arabic, Simplified Chinese, English, French, German, Hebrew, Italian, Japanese, Korean, Portuguese, Russian and Spanish); and the text flows from right to left (for Arabic and Hebrew) as well as from left to right for all other languages.

Starting the LIBPF[™] user interface

On Linux systems the user interface of LIBPF[™] is available as an executable file "UIPF" in the LIBPF_1.0 folder inside the Home user folder (~/LIBPF_1.0). It is possible to move the UIPF file in any favorite position (desktop, other folder, ...) and run it: all data, results and settings are always stored in the kernel directory (~/LIBPF_1.0).

On Microsoft Windows Vista and 7 systems, after installation, the user interface of LIBPF^M is installed in Programs \rightarrow LIBPF^M 1.0. To launch the user interface, click on UIPF:





On Windows 8 / 8.1 / 10, the user interface of LIBPF[™] runs as a traditional Desktop application, not as a Windows Store App. To start it, go to the Start screen and type "libpf"; it should find the LIBPF[™] user interface:

App Risultati per "libpf"	Cerca
LIBPF homepage	libpf 🔎
LIBPF 1.0	App 2
	Impostazioni 0
	File 0

For your convenience, at this point it is better to perform a right mouse button click on the application and select "Add to the application bar" in the lower menu:

	Арр	Risulta	ıti per "li	bpf"			
	LIBPF h	omepage					
Rimuovi da Start	Aggiungi alla barra delle applicazioni	Disinstalla	Apri nuova finestra	Esegui come amministratore	Apri percorso file		Tutte le app

In this way whenever you want to start the LIBPF[™] user interface you will find the shortcut in the Desktop application toolbar:





At launch, the interface looks like in the figure below, where you can identify the 6 main areas:

- 1) Menu bar;
- 2) Tool bar, which presents a selection of the most frequently used commands;
- 3) Tree view panel, which shows a structured view of various elements (streams, units, reactions) that make up the process;
- 4) Details view panel, where you can examine the input and results, and display the connectivity for the flowsheets.
- 5) Message panel, where diagnostic messages from the calculation engine are shown;
- 6) Status bar, where confirmation messages appear and where a small box (green in the figure) is shown at the right side, and which becomes red in case of errors.





Case management

Unlike most tools for process simulation, the LIBPF[™] user interface does not use files to save the results of the simulations, but relies on a database.

This is possible because the interface does not allow the user to change the configuration of the process, but only the operating parameters and options that have been made available by the developer of the model. The distinction between configuration (fixed for all the simulations of a process) and operating conditions (which differ from one case to another) is analogous to the distinction between classes and the instance of an object in object-oriented programming and is a hallmark of the LIBPF[™] technology.

The difference between the conventional approach and the object-oriented one of LIBPF[™] is illustrated in the following two tables:

Conventional Approach

General purpose program	Configuration Operating conditions			
	Model of process A in conditions 1 [fileA1.xls]			
Microsoft Even	Model of process A in conditions 2 [fileA2.xls]			
	Model of process B in conditions 3 [fileA3.xls]			
	Model of process B in conditions 4 [fileA4.xls]			

Object Oriented Approach of LIBPF™

Special purpose program	Operating conditions	
	Conditions 1: case A1	
	Conditions 2: case A2	
	Conditions 3: case B3	
	Ion for process B	Conditions 4: case B4

The advantages of the object-oriented approach are:

- 1. Reduces the duplication of information;
- 2. Reduces the possibility of making errors (e.g. a comparison of process A in conditions 1 and 2 requires that the Microsoft Excel files fileA1.xls and fileA2.xls



differ only on the operating conditions, and not on the calculation details of the model – but it is easy to make mistakes!);

3. Allows you to systematically update a series of scenarios (a set of cases) with a new version of the process (e.g. with more accurate models).

In a typical installation on Microsoft Windows the used database has Access format (although it is not required that Microsoft Access be installed) and is located in the persistency.mdb file in the working folder within the current user profile, typically in: C:\Program Data\LIBPF 1.0

Creating a new case

You can create a new case in the LIBPFTM user interface with the *Case* \rightarrow *New* command from the menu bar:



or with the corresponding button in the toolbar:



The program shows a dialog box which allows you to choose the process configuration (typically a single LIBPF[™] application can manage various configurations), and give a name and description to the case:



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P Nuovo	problema	? 💌				
Etichetta:	base	Descrizione: Base case				
tipi						
Carb	onBoundaryPoint	flowsheet for the calculation of the Carbon Boundary Point				
🔘 Delta	н	Verify biomass isothermal combustion enthaply change when all products are gaseous (Lower Heating Value)				
Oelta	T	Calculate biomass combustion adiabatic temperature change				
🔘 Jasp	erDanny	Danny version of JASPER gasification				
Ok	Annulla					

There are limitations regarding the allowed characters in the label and description fields:

- The first character of the description must be alphabetic, while the subsequent characters may be alphanumeric, space or any of the following characters: ,:-_{}<>[].
- The first character of the label must be alphabetic, while the subsequent characters may be alphanumeric, space or any of the following characters: ,-_{}<> thus compared to the description, the :[] characters are specifically excluded.
- By alphabetic character the characters in the a z, A Z range are intended (case sensitive), along with all the accented characters (àáâãäåèé ...) and generally all the characters considered alphabetic in the main languages (es. α ω, A Ω, A Я, a я ...);
- By alphanumeric character an alphabetic character or a digit (0 9) is intended.

When the user gives the confirmation, the interface starts the computing kernel which instantiates an object of the chosen type (DeltaT in this case) with the name ("base" in this case) and the description ("Base case" in this case) provided by the user, saves it in the database and then opens it. Note that results are not available as no calculation has been performed yet.

At the end of these operations the LIBPF[™] user interface is ready for changing the inputs and launching the calculation, see the related chapters Editing input data and Calculation).

Saving a case with a new name / description

After examining the results, you can decide to create a new case by starting with the current one, with respect to which you may wish to change some operating conditions.



For example if the current case is the "Base case" case, you might want to create a new "75 percent case" case to calculate the operating conditions at reduced load. To do this, use the *Cases* \rightarrow *Save as* command:



which duplicates the current case in the database, applying the provided description:

UIPF				
Problemi Calcola Vista	Strumenti Impost	azioni Aiuto		
📑 🔚 Þ 🗉 🖽	도 🏠 🚖			
Etichetta Descrizione	Тіро	Input Configurazio	ne Risultati	Mess:
👂 🎪 base 🛛 Base case	DeltaT	Etichetta	Valore	I A
	P Digita la nuova	a des 😵 💌	20900000	m ≡
	Descrizione per il n	uovo problema:	3349,44	m
	75 percent case		0,002	m
	ОК	Cancel	0,0315	
	-	5 :psi	0,02044	*

For the characters accepted in the description field, the limitations specified at the Creating a new case chapter apply; a description like "75% case" is not accepted because the % character is not allowed.

Beware: the new case is not immediately loaded in the interface: you must explicitly retrieve the new case, in the manner described in the next chapter Retrieving an existing case.

As more fully explained in the Editing input data chapter, any modification of the operating conditions via the graphical interface is immediately applied to the current case. This is why it is important to use the *Save as* command and then immediately load the new case before you start editing anything, otherwise you'll be modifying the current case!



Retrieving an existing case

As you proceed with the work, all the generated cases are saved in the database. At any time you can re-open a previously created case with the Cases \rightarrow Open command:

Pro	blemi Calcola Vista	
	Nuovo	Ŧ
6	Apri	E
	Salva con nome	L
	Elimina	L
>	Svuota	L
0	Esci	L

or with the corresponding button on the toolbar:



The program will then display a list of the existing cases, from which you can choose the one of interest:

Etichetta Descrizione			Tipo	Descrittivo del tipo		
1	base	Base case	DeltaT	Calculate biomass combustion adiabatic temperature change		
2	base	75 percent case	DeltaT	Calculate biomass combustion adiabatic temperature change		
3	test	calcolo del delta T adiabatico	DeltaT	Calculate biomass combustion adiabatic temperature change		
4	baseCase	Feed1 Ore	JasperDanny	Danny version of JASPER gasification		

Beware: after loading the case the calculation isn't launched: the cases are saved in the database immediately after being calculated, thus the graphical interface can restore the complete state (input and results).



Troubleshooting

If for any reason the current case is no longer of interest, you can delete it from the database with the Cases \rightarrow Delete command:



Note: the command is available only after having loaded the case.

<u>Nota bene</u>: the deletion of a case is an irreversible process, and does not require confirmation: proceed with caution!

Also, if there are too many cases in the database, or you want to reset the work done, you can clear the database completely. For this purpose you can use the *Cases* \rightarrow *Empty* command:



Nota bene: emptying the database completely is an irreversible process and with extensive consequences (e.g. it also deletes cases generated with another LIBPF[™] application that are saved in the database, even if they are invisible from the interface), this is why an explicit confirmation is required:





If in doubt, it is advised to make a backup copy of the database (persistency.mdb in the working folder location mentioned at page 6 above) manually (copy-past the file) in a separate location (i.e. Documents\backupDataBases).

Organization of objects and sub-objects

When a case is opened with the interface, a structured view of various elements (streams, units, reactions) that make up the process is displayed in the tree view panel. The program uses various icons to indicate the type of object:

Icon	Description
-\$	flowsheets and sub-flowsheets
	the folder containing all the streams
	the folder containing all the units
⇒	a material stream
•	a phase (normally contained in a stream)
	a unit (e.g. a compressor or a reactor)
	a chemical reaction
	a multi-reaction (a particular type of reaction that shifts the species
	from one stream to another, used in the membrane and fuel cell
	unit)
?	unknown object (this icon should never appear)

Just after opening a case, the root element (the one at the top) represents the current case. You can navigate through the objects and sub-objects by double-clicking (single clicking on linux systems) on the line in the tree view, which changes the selected object: as you enter the tree structure, it only shows more objects contained in the current object.

For example starting with this kind of view:



LIBPF USR manual en.odt

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_						-			
Eti	Etichetta						Descrizione	Тіро	^
⊿	8	ba	se				Base case	JasperDanny	
	\triangleright		Streams						
	4	🔟 Units							
			\boxtimes	Air	Blowe	r	Blower for gasification air	Compressor	
	☑ AirPreHeater			PreHe	ater	Air pre-heater	FlashDrum		
	BioPreHeater		ater	Biomass pre-heater	FlashDrum				
	 CondensePump GasMediumPreHeater Gasifier 		ePump	Condese pump	FlashDrum				
			umPreHeater	Gasifing medium pre-heater	FlashDrum				
				Gasifier	PerfectMixedStageGasificationPluggable				
	Streams		ms						
	Inits					Ε			
				⊿	🖾 R	СОМВ	Combustion reactor	FlashDrum	
					-	reactions[0]	embedded Reaction 0	ReactionOxidationCH4	
					-	reactions[1]	embedded Reaction 1	ReactionOxidationH2	
					-	reactions[2]	embedded Reaction 2	ReactionOxidationCO	
					-	reactions[3]	embedded Reaction 3	ReactionOxidationC	
					-	reactions[4]	embedded Reaction 4	ReactionOxidationNH3	
					-	reactions[5]	embedded Reaction 5	ReactionOxidationMeOH	
					-	reactions[6]	embedded Reaction 6	ReactionOxidationC2H4	
					-	reactions[7]	embedded Reaction 7	ReactionOxidationPhenol	
					-	reactions[8]	embedded Reaction 8	ReactionOxidationNaphthalene	
				⊳	🖾 R	EQ	Equilibrium reactor	FlashDrum	
				⊳	R	РҮ	Pyrolysis reactor	FlashDrum	

by double-clicking on the Gasifier the view will change this way:

Eti	chett	ta			Descrizione	Тіро
4	8	Jas	sper	Danny:Gasifier	Gasifier	PerfectMixedStageGasificationPluggable
	\triangleright		Str	eams		
	4		Un	its		
		⊿		RCOMB	Combustion reactor	FlashDrum
				reactions[0]	embedded Reaction 0	ReactionOxidationCH4
	reactions[1]				embedded Reaction 1	ReactionOxidationH2
				reactions[2]	embedded Reaction 2	ReactionOxidationCO
				reactions[3]	embedded Reaction 3	ReactionOxidationC
				reactions[4]	embedded Reaction 4	ReactionOxidationNH3
				reactions[5]	embedded Reaction 5	ReactionOxidationMeOH
				reactions[6]	embedded Reaction 6	ReactionOxidationC2H4
	reactions[7]				embedded Reaction 7	ReactionOxidationPhenol
				reactions[8]	embedded Reaction 8	ReactionOxidationNaphthalene
		⊳	\boxtimes	REQ	Equilibrium reactor	FlashDrum
		\triangleright	\boxtimes	RPY	Pyrolysis reactor	FlashDrum
			\boxtimes	SEP	Phase separator	Splitter
			\boxtimes	sink	Destination for all streams exiting the gr	Terminator
			\boxtimes	source	Source of all feed streams to the graph	Terminator

note the full path to the object: JasperDanny:Gasifier; in the full paths towards the variables the colon character is used (:) to separate objects from the sub-objects, and period (.) to separate the object from the variable.



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Continuing the examination of the sub-objects contained by the Gasifier, by double-clicking on RCOMB the tree view will become:

Etich	etta	Descrizione	Тіро
4	JasperDanny:Gasifier:RCOMB	Combustion reactor	FlashDrum
	reactions[0]	embedded Reaction 0	ReactionOxidationCH4
	reactions[1]	embedded Reaction 1	ReactionOxidationH2
	reactions[2]	embedded Reaction 2	ReactionOxidationCO
	reactions[3]	embedded Reaction 3	ReactionOxidationC
	reactions[4]	embedded Reaction 4	ReactionOxidationNH3
	reactions[5]	embedded Reaction 5	ReactionOxidationMeOH
	reactions[6]	embedded Reaction 6	ReactionOxidationC2H4
	reactions[7]	embedded Reaction 7	ReactionOxidationPhenol
	reactions[8]	embedded Reaction 8	ReactionOxidationNaphthalene

and lastly by double clicking on reactions[1] only the current object will be shown (as the reaction does not contain sub-objects):

Etichetta			Descrizione	Тіро
		JasperDanny:Gasifier:RCOMB:r	embedded Reaction 1	ReactionOxidationH2

note the full path to the object: JasperDanny:Gasifier:RCOMB:reactions[1]; for the vectorial objects or variables the square brackets [] suffix operator selects the object of interest with an integer index starting from zero, for example reactions[0] is the first reaction and x[5] is the sixth mole fraction.

The Stream folder contains Stream-type objects each with the thermodynamical state (T, P) and the Phases as sub-objects, both the separate phases that compose the material and the total phase (if there is more than one phase). The Units folder contains sub-flowsheets and unit operations, each with its operating specifications and key performance data (deltaP, duty, deltaH, deltaS, efficiencies, …). Unit operations can also contain the reactions with their stoichiometric coefficients, equilibrium constants and rate of conversion.

To go in the structure up with a single level, you can use the *View* \rightarrow *Up* command from the menu bar:



Problemi Calcola	Vista Strumenti Impostazioni Aiuto
	 Espandi tutti Contrai tutti
Etichetta	🟫 Radice
JasperDann	🛧 Su
	Risultati per le correnti in formato ODS Risultati per le correnti in formato XLS

or the corresponding button in the toolbar:

umenti	Impostazioni
© 🏠	🚖 🔂
	De Su one
COMB:r	embedded Re

To go up again to the highest level in the structure you can use the *View* \rightarrow *Root* command in the menu bar:

roblemi Calcola	Vista	Strumenti Impostazioni Aiuto
	Đ	Espandi tutti
	ē	Contrai tutti
Etichetta		Radice
 JasperDann 	*	Su
		Risultati per le correnti in formato ODS
	x	Risultati per le correnti in formato XLS

or the corresponding button in the toolbar:



Once the object of interest selected, you can examine the details in the panel at the right (details view) which has five tabs:

- Input: user-specified parameters, read-write
- Configurations: enable and disable select additional equations, read-write
- Results: selection of key results, read-only



- Messages: warnings and errors, read-only
- and PFD (Process Flow Diagram), clickable.

The last tab is active only for flowsheets and sub-flowsheets, and allows to see their process scheme and zoom in or out, and to examine the sub-objects by interactively clicking on the units or streams in the PFD view: the effect is equivalent to a double click on the corresponding object in the tree view on the left.

Simulation

Editing input data

The user interface allows you to set the operating parameters and conditions and change the options that have been made available by the developer of the model. This implies that some input parameters could be inaccessible, because the developer of the model considered them unattractive or even dangerous to handle (e.g. for the stability, accuracy and convergence of the model).

With these limitations, editing is very straightforward: just browse the tree view and identify the stream, unit, sub-flowsheet or reaction you want to edit, and double-click. For example if you want to change an input parameter relative to the reaction[0] reaction of BiomassReaction_pyro_max type in the RPY unit of FlashDrum type found in the Gasifier sub-flowsheet of PerfectMixedStageGasificationPluggable type, just browse the tree view and double click on the Gasifier:RPY:reactions[0] object:

Etichetta			Descrizione	Тіро				
⊿	8	tes	est			test case	JasperDanny	
	\triangleright		Str	Streams				
	⊿		Un	its				
	⊠ AirBlower		Blower	Blower for gasification air	Compressor			
	 ☑ AirPreHeater ☑ BioPreHeater ☑ CondensePump ☑ GasMediumPreHeater 		PreHeater	Air pre-heater	FlashDrum	_		
			PreHeater	Biomass pre-heater	FlashDrum	=		
			ndensePump	Condese pump	FlashDrum			
			MediumPreHeater	Gasifing medium pre-heater	FlashDrum			
	4 <mark>-🔹 Gasifier</mark>		ifier	Gasifier	PerfectMixedStageGasificationPluggable			
	Streams		Streams					
	 Inits 		Units					
	⊳ 🗵 RCOMB		RCOMB	Combustion reactor	FlashDrum			
	⊳ 🖾 REQ		🖾 REQ	Equilibrium reactor	FlashDrum			
	A 🖾 RPY		⊠ RPY	Pyrolysis reactor	FlashDrum			
					reactions[0]	embedded Reaction 0	BiomassReaction_pyro_max	
					⊠ SEP	Phase separator	Splitter	
					⊠ sink	Destination for all streams exiting the g	Terminator	-



so that you change the tree view, which shows now the current object:

Etichetta	Descrizione	Тіро
■ JasperDanny:Gasifier:RPY:reactions[0]	embedded Reaction 0	BiomassReaction_pyro_max

The details view panel now shows a filtered view of the details relative to the selected reaction; particularly clicking on the Input tab the input variables that can be manipulated (only one in this case, the conversion) are shown:

Input		Configurazio	ne	Risulta	ti Messaggi	PFD
		Etichetta	Val	lore	Unità di misura	Descrizione
1	:z		1	2		Fractional conversion in terms of key component

At this point just click in the box and type in the new value:

In	nput	Configurazion	e Risulta	ti Messaggi	PFD
		Etichetta	Valore	Unità di misura	Descrizione
1	1 :z		0,8]		Fractional conversion in terms of key component

The change becomes effective after you press Enter or click on another element in the user interface (i.e. removing the focus from the input field).

Any change made to the operating conditions carried out this way via the graphical interface is immediately updated in the database with reference to the current case. For this reason explicitly saving the changes as we are used to do in other programs isn't necessary: the *Cases* \rightarrow *Save* does not even exist, there is instead *Cases* \rightarrow *Save* as, which is used to create a copy of the current case (see the Saving a case with a new name / description related chapter).

Calculation

When a new case is created, results are not available as no calculation has been performed yet (see Creating a new case). Also if an existing case is loaded (see Retrieving an existing case) or the current case is edited (see precedent chapter Editing input data), you need to explicitly launch the calculation.



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This logic is advantageous if the simulation runs are of considerable duration: if the calculation started automatically after each change, this could render the graphical interface interface unresponsive.

In any case you can launch the calculation of the current case with the Calculate \rightarrow Calculate command:

Problemi	Calo	cola	Vista	Stru
	KK	Res	etta	10
	\triangleright	Cal	qola	Ē
Etichetta		Sto	p	Т

or with the corresponding button in the toolbar:



The calculation is delegated from the graphical interface to an executable, the calculation kernel, which is launched as a separated process, as you can see from the notice indicated in the status bar at the bottom right.



During the calculation in the bottom panel (of the messages) the diagnostic messages coming from the kernel are shown in real time, in order to monitor the progress of the calculation. A typical trace in case of success would be:

I	main * Define components
I	main * Define flowsheet
I	main * Retrieving 619 from persistent storage database
I	main * Define cut streams convergence
I	main * Starting computation
I	FlowSheet <class zerozero="">::calculate * Iter = 0 Error = 0.023535</class>
I	FlowSheet <class zerozero="">::calculate * Iter = 1 Error = 0.00105955</class>
I	FlowSheet <class zerozero="">::calculate * Iter = 2 Error = 5.08785e-005</class>
I	FlowSheet <class zerozero="">::calculate * Iter = 3 Error = 3.75563e-006</class>
I	FlowSheet <class zerozero="">::calculate * Iter = 4 Error = 1.22477e-006</class>
I	FlowSheet <class zerozero="">::calculate * Iter = 5 Error = 4.54359e-007</class>
I	main * Computation complete
I	main * Updating results to persistent storage
I	main * Save stream table in ODF format
I	main * Program exits correctly
I	



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If instead during the calculation errors occur, these are highlighted in red in the messages panel:

===== Logging error negative material flow in test:AirToICE
===== Logging error exceeded maximum iterations limit in test:Gasifier:REQ
===== Logging error Flash convergence failure in FlashDrumBase::calculate; in test:Gasifier:REQ
FlowSheet <class zerozero="">::calculate * Iter = 9 Error = 1.27904e-006</class>
===== Logging error exceeded maximum iterations limit in test:Gasifier:REQ
===== Logging error Flash convergence failure in FlashDrumBase::calculate; in test:Gasifier:REQ
===== Logging error negative material flow in test:AirToICE
===== Logging error exceeded maximum iterations limit in test:Gasifier:REQ
===== Logging error Flash convergence failure in FlashDrumBase::calculate; in test:Gasifier:REQ
FlowSheet <class zerozero="">::calculate * Iter = 10 Error = 6.39521e-007</class>
main * Computation complete
main * Updating results to persistent storage
===== Logging error exceeded maximum iterations limit in test:Gasifier:REQ
main * Save stream table in ODF format
main * Program exits correctly

In these anomalous situations the duration of the calculation could go on for too long, and seen the encountered errors the results will certainly be devoid of interest; if needed in these cases you can stop the calculation using the *Calculate* \rightarrow *Stop* command:

Problemi	Calo	ola	Vista	Stru
	[KK]	Res	etta	10
	\triangleright	Cal	cola	E
Etichetta		Sto		Т

or with the corresponding button in the toolbar:



At the end of every calculation you can examine the results in the manner specified in chapter Examining the results.

Homotopy

Homotopy is a globally convergent numerical continuation method for solving systems of non-linear equations. With homotopy, to solve a complex problem, you solve first a simpler problem and then continuously transform it so that its solution is transformed into the solution of the complex problem. During this transformation it is possible to track what happens to the equations and to the solution, so that the speed of the deformation can be adapted.



Within the LIBPF[™] User Interface it is possible to to solve in homotopy mode:



This solution mode is useful when the process is very sensitive to changes to certain input parameters, or when the desired step change for those parameters is relatively large. In Homotopy mode all the input variables whose values have been changed by the user since the last computation are moved simultaneously and gradually from the previous state to the new desired state, repeatedly solving the model for the intermediate values.

Examining the results

Calculation status

At the end of a calculation or even after having created a new case the user interface will display something similar to this figure:



Problemi Calcola Vista Strumenti Impost	azioni Aiuto					
📑 🔚 🖻 🖻 🏫 🛧 🖬 🖬 💌						
Etichetta Descrizione Tipo	Input Config	urazione Risultati	Mess			
b ase Base case DeltaT	Etiche	etta Valore	<u> </u>			
	1 :biomassL	HV 20900000	m≡			
	2 :cp	3349,44	m			
	3 :dp	0,002	m			
4 :phi 0,0315						
5 :psi 0,02044 🛫						
SolverNleInterface::solve * 0 1.10434e-005 max residual: 0.00469965 in DeltaT:S03:T Logging error flowsheet sequential convergence failure: maximum iterations reached; in DeltaT						
SolverNleInterface::solve * 1 1.37008e-012 max residual: 1.65535e-006 in DeltaT:S03:T_ main * Computation complete main * Saving results to new-style persistent storage main * Done saving results to new-style persistent storage 1.186 main * Save stream table in ODF format main * Program exits correctly						
		Il nodo 426 è stato a	perto			

Firstly note in the status bar at the bottom right the "Node 426 has been opened" notification: this number is internally used by the database to uniquely identify the current case.

In the top left panel (tree view) the program uses color codes to indicate at a glance the status of the last calculation:

• white indicates: no error nor warnings:



• yellow indicates: there are warnings:

Etichetta	Descrizione	Tipo
▷ <mark>-</mark> ᡚ base	Base case	JasperDanny

• red indicates: there are errors:

Etichetta	Descrizione	Тіро
Þ 🔯 base	Base case	JasperDanny



In case of warnings or errors the color codes are displayed on each object to make the search for the cause easier:

Etichetta			Descrizione	Тіро		
⊿	4 🔯 base			Base case	JasperDanny	
	Streams		eams			
	 Units 		its			
			\boxtimes	AirBlower	Blower for gasification air	Compressor
				AirPreHeater	Air pre-heater	FlashDrum
			\boxtimes	BioPreHeater	Biomass pre-heater	FlashDrum
CondensePump		CondensePump	Condese pump	FlashDrum		
SasMediumPreHeater		GasMediumPreHeater	Gasifing medium pre-heater	FlashDrum		
		⊳	8	Gasifier	Gasifier	PerfectMixedStageGasificationPluggable
		\triangleright	\boxtimes	ICE	Internal combustion Engine	ICE
⊠ Mix1 ⊠ Split1 <mark>⊠ SynGasCond</mark>		\boxtimes	Mix1	Gasifing medium mixer	Mixer	
		\boxtimes	Split1	Condense splitter	Divider	
		SynGasCond	Syngas condenser	FlashSplitterDrum <streamidealliquidva< th=""></streamidealliquidva<>		
				SynGasCooler	Syngas cooler	FlashDrum
		Þ		TarCracker	Tar cracker reactor	FlashDrum
			\boxtimes	sink	Destination for all streams exiting the gr	Terminator
			\boxtimes	source	Source of all feed streams to the graph	Terminator

From this example you can see that the ("base") case contains errors (red line) because the Gasifier and SynGasCond sub-objects contain errors. The AirPreHeater, GasMediumPreHeater, SynGasCooler and Tar Cracker contain warnings (yellow lines), but the errors prevail in determining the global state of the case.

Details and descriptions about the errors and warnings can be found in the Messages tab for each unit, with the same color conventions of yellow for warnings and red for errors:



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Results

You can find the results for various units and streams in the "Results" tabs from the panel at the right (details view) by browsing through the objects and sub-objects as shown in the Organization of objects and sub-objects chapter.

These tables allow selecting a subset of cells or the entire table, and copying that to the clipboard:

	Etichetta	Valore	Unità di misura	Descrip
1	:cduty	0	m^2 kg s^-3	Cumulative enthalpy flow inle
2	:cmdot	0	kg s^-1	Cumulative mass flow inlet m
3	:purity[0]	0,2692618455		purity CO2
4	:purity[1]	0,6894686168		purity CH4
5	:purity[2]	0,04126953771		purity H2O
6	:recovery[0]	0,6781939785		recovery CO2
7	:recovery[1]	0,9840593245		recovery CH4
8	:recovery[2]	0,5890285999		recovery H2O
9	TestMembraneFreeFlowMulti:FEED:P	650000	m^-1 kg s^-	Copy Ctrl+C
10	TestMembraneFreeFlowMulti:FEED:T	333,15	ĸ	Select All Ctrl+A



2015/04/21

For the selection in the screen-shot, the text copied to the clipboard will include the column header and the content of the selected cells, with tabs (character \rightarrow I)as separators of the fields:

Tag→lValue→lUnits
:purity[0]→10,269262→1
:purity[1]→10,689469→1
:purity[2]→10,0412695→1
:recovery[0]→10,678194→1
:recovery[1]→10,984059→1
:recovery[2]→10,589029→1
TestMembraneFreeFlowMulti:FEED:P→I650.000→Im^-1 kg s^-2

The content of the clipboard can then be directly pasted to a spreadsheet, and the tabs will be interpreted as column separators.

The results for the material streams (material and energy balances) can be exported to a spreadsheeting program such as Microsoft Excel (if available) on the supported Microsoft Windows operating systems, or LibreOffice / OpenOffice (if available) on all supported operating systems, as shown in the following two paragraphs.

Concerning numerical values, the LIBPF[™] user interface uses the global system settings for the number formats (comma or dot as decimal separator etc.).

Units of measurement (UOM)

The LIBPFTM user interface currently supports three sets of units of measurements: SI (International System of Units), EN (imperial units) e Eng (engineering units). The default settings is SI, which is also the unit sets internally used by the kernel for all the computations. It is possible to change the units of measurements for all the variables by selecting the menu Settings \rightarrow Units:



Settings Help Image: Settings Image: Settings Image: Settings Image: Settings Image: Settings Settings Image: Setting	
Image Image <td< th=""><th></th></td<>	
Select kernel puts Config Outputs Messages PFD Image Image <td></td>	
Imits SI Error Imits EN Sg[0] convergence on deltax; du Imits Eng Sg[0] convergence on deltax; du	5
Language > EN sg[0] convergence on deltax; du Eng sg[1] BY reactions[1]: Zero flow of	or/
Eng and LL PV reactions (L) V Toro flow a	bi
Compressor sg[1] Kareactions[1]:2ero now c	of
Ip Exchanger	of
FlashDrum	
Compressor f Terminator	

Whenever the global unit setting is changed, all inputs and results are presented in the selected units from that moment on, and the previously set values are converted so that results must actually be unchanged.

Besides these global units of measurements settings, the LIBPF[™] user interface also supports setting units for each individual variable, both in input and in output forms. These settings can be changed by pulling down the combo boxes "Units of measurements" found to the right of each variable. As soon as the unit is changed, values are automatically converted.

powerEl	497715,4217	kW	Total net electric output
powerIn	1428.47	MW v	Lower Heating Value input
		BTU/h	4
		MW	
		W kW kcal/h kcal/s m^2 kg s^-3	

The supported units of measurements are listed in the following table, grouped by the underlying physical quantity:

acceleration	m/s2	charge	
adimensional			J/kmol
amount	mol	amount an acifia anarau	kJ/kmol
amount flow	kmol/s	amount specific energy	BTU/lbmol
	kmol/h		kcal/kmol
	lbmol/h		J/(kmol*K)
	mol/h	amount specific entropy	J/kmol/K
	mol/s		kJ/kmol/K
	Nm3/h	angle	rad
	Nm3/d	area	m2
amount specific electric	C/kmol		dm2



$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		ft2		kcal/(h*m2*K)
$\begin{array}{c c c c c c c c c c c c c c c c c c c $		cm2		BTU/(h*ft2*F)
A/m2 A/dm2heat transfer resistance inductancem2*K/W m2 inductanceareic current $A/f2A/cm2mA/cm2inverse of lengthinverse of molecularweightmol/kgareic electric resistanceconductanceFmol/kgcapacitanceFinverse of molecularweightmol/kgconductanceSmol/kgconductanceSmol/kgcurrentAmdensityg/m3g/m3g/m3length *timemdiffusivitym2/smmdynamical viscositycPluminous intensitycdelectric resistanceohmmasstdynamical viscosityVmBa'smagnetic fluxWbelectric resistanceohmmasstmmBTUmmBTUggenergyK/kg/dt/henergy price\xi/J\xi/Jkg/dentropyJ/Kmass flowkg/JentropyJ/Kmass specific energyJ/kgentropyJ/Kmass specific energyJ/kg'entropyJ/Kmass specific heatkJ/kgJ/kg'K)forceNmass specific heatka/l/kJ/kg'K)frequencyHzcapacityKal/kg'K)hat it ransfer coefficientkg/m7mass specific heatkcal/kg/KJ/kg'K)$		mm2		W/m2/K
A/dm2 A/ft2inductanceHareic currentA/ft2 A/cm2 mA/cm2 ohm*m3 ohm*m3 		A/m2	heat transfer resistance	m2*K/W
areic current A/ft2 A/cm2 mA/cm2 mA/cm2 ohm*m2 ohm*m2 ohm*m2 ohm*m2 ohm*cm2 ohm*		A/dm2	inductance	Н
areic current $A/cm2$ $A/mm2$ inverse of molecular weightkmol/kgareic electric resistanceohm*m2 ohm*cm2weightmol/kgcapacitanceFinverse of molecular weightmol/kgcapacitanceSmftcurrentAftkg/m3 b/ft3lengthdmdiffusivitym2/sumpa*slength*timem*sdynamical viscosityCPluminous intensitycdpaeter coststanceohmmgelectric resistanceohmmggJggelectric resistanceohmmasstohmmBTUkg/skg/nenergy KVh masstffg/dt/henergy price ξ/J g/dentropyJ/Kmass specific energyg/dentropyJ/Kmass specific energymJ/kgfKxalJ/kgkcal/kgentropy powerMV/kmass specific energyflow coefficientkg/m7mass specific energyflow coefficientkg/m7mass specific heatflow coefficientkg/m7mass specific heatfrequencyHzcapacitykcal/kg/kfrequencyHzcapacitykcal/kg/k		A/ft2	inverse of length	1/m
$A/mm2$ mA/cm2weight inverse of molecular weightkmol/kgareic electric resistance ohm*cm2ohm*cm2 ohm*cm2weightmol/kgcapacitance currentFinverse of temperature1/Kconductance currentAftftdensitymg/m3 ib/ft3lengthdmdiffusivitym2/slengthmmdiffusivitym2/slength*timem*sdynamical viscosity electric chargeCmagnetic fluxWbelectric resistance ohmVmgmgdiffusivitym2/slength*timem*sdynamical viscosity electric chargeCmagnetic fluxWbelectric resistance magnetic fluxmgmgenergyJmmBTUkg/afKwhg/dkg/afKxalkg/afKwhg/denergy price ξ/J mass flowg/dentropy power K/K mass specific energyM/kgentropy powerM/Kmass specific energyM/kgfM/Kmass specific heatJ/kgentropy powerM/Kmass specific heatJ/kgfmass specific heatJ/kg/kjfmass specific heatJ/kg/kjfmass specific heatJ/kg/kjfmass specific heatJ/kg/kjfmass specific heatJ/kg/kjfmass specific heatJ/kg/kjfmass specific	areic current	A/cm2	inverse of molecular	
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areic electric resistance capacitance phm^*cm2 ohm*cm2weight $model mathematical stresscapacitanceFinverse of temperature1/KconductanceSftcurrentAftdensityg/m3g/m3b/ft3lengthdmdiffusivitym2/slength*timem*sdynamical viscosityPa*slength*timem*sdynamical viscosityCmagnetic flux densityTelectric chargeCmagnetic flux densityTelectric resistanceohmmsstJJggenergy\frac{f(J)}{MWh}\frac{f(J)}{K}mass flowt/denergy price\frac{f(J)}{MWh}\frac{f(Kcal}{f(Kcal})mass per unit workkg/JentropyJ/Kmass specific energyMJ/kgentropyJ/Kmass specific energyMJ/kgfitureg/m2/smass specific energyMJ/kgfitureg/m2/smass specific energyMJ/kgfitureg/m2/smass specific energyMJ/kgfitureg/m2/s2mass specific heatJ/(kg*K)forceNmass specific heatJ/(kg*K)frequencyHzcapacitykcal/kg/k$		ohm*m2	inverse of molecular	mol/ka
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$\begin{array}{c} \mbox{conductance} & S & & & & & & & & & & & & & & & & & $	capacitance	F	inverse of temperature	1/K
currentAkg/m3 g/m3 lb/ft3lengthkmdensity $mg/m3$ g/m3 lb/ft3lengthkmdiffusivitym2/sumdynamical viscositycP mPa*slength*timem*sdynamical viscositycPluminous intensitycdmPa*smagnetic fluxWbelectric chargeCmagnetic flux densityTelectric resistanceohmmsstbJggenergymmBTU Kcal $€/LJ$ kg/senergy price $€/J$ kg/s $€/LJ$ $€/LJ$ mass flowt/h $€/LJ$ t/ht/h $€/LS$ $€/RCal$ $€/Rcal$ gentropyJ/Kmass specific energyMJ/kgentropyJ/Kmass specific energyMJ/kgflow coefficientkg/m7 forcemass specific heat $J/(kg^*K)$ mass specific heat $J/(kg^*K)$ frequencyHz heat transfer coefficientmassJ/kckat transfer coefficientW/m2*K)mass specific heat capacityJ/(kg*K)	conductance	S		m
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In the second systemib/ft3ib/ft3diffusivitym2/simmPa*slength*timem*sdynamical viscositycPluminous intensitycdclict chargeCmagnetic fluxWbelectric chargeCmagnetic flux densityTelectric potentialVkggJmasstenergyMWhkg/skg/hkcalkg/dkg/d ℓ/J g/dg/denergy price ℓ/J g/d ℓ/J mass flowg/d ℓ/J t/d ℓ/J mass per unit workkg/Jenergy price $\ell/Kcal$ J/kg ℓ/J mass per unit workkg/J ℓ/J mass specific energyMJ/kgflow coefficientkg/m7mass specific heatJ/(kg*K)flow coefficientkg/m7mass specific heatJ/(kg*K)flow coefficientkg/m7mass specific heatJ/(kg*K)flow coefficientkg/m7mass specific heatJ/(kg*K)flow coefficientkg/m7mass specific heatJ/(kg*K)forceNmass specific heatJ/(kg*K)frequencyHzmass specific heatJ/(kg*K)heat transfer coefficientW/(m2*K)mass specific heatJ/(kg*K)heat transfer coefficientW/(m2*K)mass specific heatJ/(kg*K)heat transfer coefficientW/(m2*K)mass specific heatJ/(kg*K)<	density	a/m3	longal	cm
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$\begin{array}{c c c c c c c } & Pa^*s & elegth*time & m^*s \\ \hline dynamical viscosity & cP & luminous intensity & cd \\ mPa^*s & magnetic flux & Wb \\ electric charge & C & magnetic flux density & T \\ electric potential & W & mg \\ electric resistance & ohm & mss & t \\ J & & mBTU & mg \\ energy & & MWh & kcal & kg/s \\ \hline Kcal & kWh & & g/d \\ \hline \ell/J & & & & & & & & \\ \hline \ell/J & & & & & & & & \\ \hline energy price & & & & & & & & & \\ \hline \ell/kcal & & & & & & & & & & \\ \hline entropy & J/K & & & & & & & & & \\ entropy power & & & & & & & & & & & & \\ \hline flow coefficient & kg/m7 & & & & & & & & & & & & \\ frequency & Hz & & & & & & & & & & & & & & & & & $	diffusivity	m2/s		um
$\begin{array}{c c c c c } dynamical viscosity & cP & \\ mPa*s & magnetic flux & Wb & \\ merge & C & \\ electric charge & C & \\ electric potential & V & \\ mV & \\ electric resistance & ohm & \\ & \\ & \\ & \\ & \\ & \\ & \\ & \\ & \\ & $	amaerriy	Pa*s	length*time	m*s
electric charge C C magnetic flux Wb electric potential V mV g mg electric resistance ohm mass t b g mg energy MWh kcal kg/s kg/h kg/d kg/d kg/d kg/d kg/d kg/d kg/d kg/d	dynamical viscosity	cP	luminous intensity	cd
electric chargeCmagnetic flux densityTelectric potentialVmgelectric resistanceohmmassBTUBTUenergymmBTUKcalKg/dKWhKg/d ξ/J Kg/d ξ/J Kg/denergy price ξ/J $\xi/Kcal$ mass per unit work $\xi/kcal$ BTU/h°Fflow coefficient g/d forceNfrequency Hz heat transfer coefficient $W/(m2*K)$		mPa*s	magnetic flux	Wb
electric potential V mV mV mV mV mV mS mS $mass$ $mass$ $mass$ $mass$ $massmass$ $mass$	electric charge	C	magnetic flux density	T
electric potential mV electric resistanceohmmg J BTU $mass$ BTU g energy MWh kg/s kg/d kg/d kWh kg/d kVh kg/d kVh kg/d kVh kg/d kVh kg/d kVh kWh kVh kg/d kI/d kg/d k		V		ka
electric resistanceohmmasst J BTU g BTU $mmBTU$ g $mmBTU$ kg/s $kcal$ kWh $kcal$ kWh ℓ/J	electric potential	mV		ma
$\begin{array}{c c c c c c c } & J & & & & & & & & & & & & & & & & & $	electric resistance	ohm	mass	t
$\begin{array}{c} \mbox{energy} \\ e$		J		lb
$\begin{array}{c} \mbox{energy} & \mbox{mmBTU} \\ MWh \\ kcal \\ kWh \\ \hline kcal \\ kWh \\ \hline kCal \\ \hline kWh \\ \hline kmBTU \\ \hline kmmBTU \\ \hline k/J \\ \hline k/mmBTU \\ \hline k/J \\ \hline k/mmBTU \\ \hline k/kWh \\ \hline k/kWh \\ \hline k/kcal \\ \hline k/kc$		BTU		a
energyMWh kcal kWh kCal kWhkcal kg/h kg/d ℓ /J ℓ /J ℓ /J ℓ /J ℓ /mmBTU ℓ /mmBTU ℓ /d ℓ /MWh ℓ /kWh ℓ /kWh ℓ /d ℓ /kWh ℓ /kWh ℓ /kCal ℓ /kcal ℓ /kcal ℓ /kCal ℓ /kcalentropyJ/K J/kg kCal/kgentropy power W/K $BTU/h/°FMJ/kgkJ/gflow coefficientfrequencykg/m7forceNmass specific heatcapacityfrequencyheat transfer coefficientW/(m2*K)$		mmBTU		ka/s
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	energy	MWh		ka/h
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $		kcal		ka/d
$ \begin{array}{c c} \hline \\ \hline \\ \hline \\ energy price \end{array} & \hline \\ \hline \\ \hline \\ \hline \\ energy price \end{array} & \hline \\ \hline \\ \hline \\ \hline \\ \hline \\ \\ \hline \\ \\ \hline \\ \\ energy price \end{array} & \hline \\ \hline \\ \hline \\ \\ \\ \hline \\ \\ \\ \hline \\ \\ \\ \hline \\ \\ \\ \\ \hline \\ \\ \\ \\ \\ \hline \\ \\ \\ \\ \\ \hline \\$		kWh		a/d
energy price€/mmBTU \$/mBTU \$/J €/kWh €/kWh €/kCal €/kcal €/kcal €/kcalt/d t/yr Ib/hentropy entropy powerJ/K €/kCal €/kCal €/kCalJ/kg kCal/kg BTU/h/°Fflow coefficient force forceN Hz heat transfer coefficientW/(m2*K)w/(m2*K)W/(m2*K)		€/J	mass flow	t/h
\$/mmBTU\$/J\$/J€/kWh€/kWh€/kCal€/kcal€/kcal€/kcal€/kcal€/kcalBTU/h°Fflow coefficientkg/m7forceNfrequencyHzheat transfer coefficientW/(m2*K)		€/mmBTU		t/d
energy price\$/JIb/h\$/J€/kWhIb/h€/kWh€/kWhJ/kg€/kcal€/kcalBTU/lb€/kcalW/KBTU/lbentropy powerW/KKJ/gflow coefficientkg/m7mass specific heatforceNmass specific heatJ/(kg*K)frequencyHzcapacityJ/(kg*K)heat transfer coefficientW/(m2*K)mass specific heatJ/(kg*K)		\$/mmBTU		t/vr
energy price $\overbrace{\ell/kWh}$ \fbox/kWh $\fbox/kcal$ $€/kcal$ $€/kcal$ mass per unit workkg/J $entropy$ $\overbrace{\ell/kcal}$ $€/kcal$ J/kg kcal/kg BTU/lbentropy powerJ/K BTU/h/°Fmass specific energyMJ/kg kJ/kg m2/s2flow coefficient forcekg/m7 Hz heat transfer coefficientN Hz capacitymass specific heat dlow coefficient		\$/.J		lb/h
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€/kcal €/kcalkcal/kg BTU/lbentropyJ/Kmass specific energyMJ/kg kJ/g kJ/kgentropy powerW/K BTU/h/°Fmass specific energyMJ/kg kJ/kgflow coefficientkg/m7mass specific heat capacityJ/(kg*K)frequencyHz kal/(m2*K)mass specific heat capacityJ/(kg*K) kcal/(kg*K)		€/MWh	······································	.l/ka
entropy J/K BTU/lb entropy power W/K MJ/kg flow coefficient kg/m7 mass specific energy force N mass specific heat frequency Hz capacity heat transfer coefficient W/(m2*K)		€/kcal		kcal/kg
entropyJ/Kmass specific energyMJ/kgentropy powerW/KkJ/gBTU/h/°FBTU/h/°Fflow coefficientkg/m7forceNfrequencyHzheat transfer coefficientW/(m2*K)		€/kcal		BTU/lb
with opy with opy entropy power W/K BTU/h/°F BTU/h/°F flow coefficient kg/m7 force N frequency Hz heat transfer coefficient W/(m2*K)	entropy	.J/K	mass specific energy	MJ/ka
entropy power BTU/h/°F flow coefficient kg/m7 force N frequency Hz heat transfer coefficient W/(m2*K)	onaopy	W/K	mace opcome energy	kJ/a
flow coefficient kg/m7 m2/s2 force N mass specific heat J/(kg*K) frequency Hz capacity kcal/(kg*K) heat transfer coefficient W/(m2*K) BTU/lb/°F	entropy power	BTU/h/°F		k.l/ka
force N mass specific heat J/(kg*K) frequency Hz capacity BTU/lb/°F heat transfer coefficient W/(m2*K) BTU/lb/°F	flow coefficient	ka/m7		m2/s2
frequency Hz capacity kcal/(kg*K) heat transfer coefficient W/(m2*K) BTU/lb/°F	force	N	mass specific heat	J/(ka*K)
heat transfer coefficient W/(m2*K) capacity BTU/lb/°F kcal/kg/K	frequency	Hz		kcal/(kg*K)
kcal/kg/K	heat transfer coefficient	W/(m2*K)	capacity	BTU/lb/°F
				kcal/kg/K



	l/ka/K	derivative of	
	k l/ka/K		
mass specific volume	m3/kg	pressure*molar volume	
	kmol/m3	squared	
	mol/m3	second temperature	
molar concentration	lbmol/ft3		
	mmol/dm3	derivative of specific	J/(kg*K3)
	mol/dm3	heat	
molar volume	m3/kmol	surface tension	N/m
	ka/kmol		K
	mg/Nm3	temperature	°C
molecular weight	a/Nm3	•	°F
	lb/lbmol	temperature derivative of	
money	€		kg/(m3*K)
	kmol/kg/m		
permeance	GPU	temperature derivative of	Pa/K
	W	pressure	
	BTU/h	temperature derivative of	
	kW	pressure*molar.volume	Pa*m6/kmol2/K
power	kcal/s	pressure motar volume	
	kcal/h	squared	
	GW	temperature derivative of	1////*1/0)
	MW	specific heat	J/(KY KZ)
power density	W/m2	temperature	
	Pa		K2/Pa
	MPa	squared/pressure	
	atm	temperature/pressure	K/Pa
	bar	thermal conductivity	VV/(M°K)
	barg	thermel registivity	VV/M/K
	mbar hDa	thermal resistivity	III N /VV
pressure	nra kDe	inernal resistivity	m2*K2/\\/2
	KPa mmHa	squared	
	IIIIII⊓y Torr		S
	1011 mm⊔2∩		min
	ka/cm2	time	h
	ngi ngi		d
nressure*molar volume	ры		yr
	Pa*m6/kmol2	VdW a	N*m4*kmol-2
squared		VdW a*n*n	N*m4
resistivity	ohm*m	velocity	m/s
	ohm*cm	volume	m3
second temperature	ka/(m3*K2)		ft3
derivative of density	Ng/(110 NZ)		ណាវ
second temperature			
derivative of another	Pa/K2		111113 11
uerivative of pressure	Do*m6/kmal2/K2		ui ml
	ra 1110/K111012/NZ		1111

UBP	flexible process flowshee	ting	
LIBPF_USR_man	ual_en.odt		2015/04/21
	I		l/h
volume flow	m3/s		
	m3/h		
	ft3/h		

Exporting material and energy balances to LibreOffice / OpenOffice

If a program that can open the OpenDocument ODF format such as LibreOffice or OpenOffice has been installed, you can export all the material and energy balances for the material streams table by using the $View \rightarrow Results$ for streams in ODS format command:



or with the corresponding button in the toolbar:

tazioni	Aiuto		
	x		
Ris	ultati per le corre	nti in formato ODS	essi 🕩 🕨
	Ftichetta	Valore	 ^

Note: the command is available only after having carried out the calculation.

Also in this case, the spreadsheet will open in a few seconds:



🗃 streamtable.ods - LibreOffice Calc File Modifica Visualizza Inserisci Formato Strumenti Dati Finestra ? × 🗟 • 🔚 🖯 🛯 🖂 🖾 🖉 💖 🖏 🕞 🗓 • 🝰 🗠 • 🖉 • 📓 🦕 🐝 🏼 🥔 Trova testo : 💾 Arial ▼ 10 💌 🙈 🖉 🖹 E E E 🗏 🗏 🖶 🔚 🖇 🐜 🖤 🗲 📧 F 🕶 🗾 \checkmark fix $\Sigma = Id$ A1 С D F G В н Pressure [Pa Temperature Phase tag 1 Row Complete tac Description Type ld 101325 Air inlet for g? StreamVapor 288,15 Tphase 2 1 :AirlN 1 3 3 2 :AirINHot Air preheated StreamVapor 351325 323,15 Tphase 4 5 3 :AirlNblew Air for gassift StreamVapor 351325 461,046 Tphase 5 7 4 :AirToICE Air to internal StreamVapor 101325 288,15 Tphase 6 9 5:AshOUT Ashes out to▶StreamSolid 351325 1008,04 Tphase 7 Biomass inle StreamIdeall 6:BioIN 351325 288,15 Lphase 11 8 Sphase 9 Tphase Vphase 10 11 16 10 : BiolNHot Biomass inle StreamIdealⅠ 351325 573,15 Lphase 12 Sphase

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The operating logic of this command is very different of the one described in the previous chapter, Errore: sorgente del riferimento non trovata; in this case no macro is run in {Libre, Open}Office, but rather the streamtable.ods file is directly generated starting from certain files produced by the calculation kernel (particularly contents.xml, which is produced at the end of each calculation). This implies that the streamtable.ods file is rewritten each time, thus you can't keep a "formatted" sheet that presents the same results properly formatted, as in Microsoft Excel. In addition due to the inner workings of LIBPF™, the data for each stream and each phase is arranged by row instead of column as in the case of Microsoft Excel, which makes reading difficult.

The approach to create a readable format is to create an independent {Libre, Open}Office file e.g. formatted.ods and take the fields of interest by creating a link between the formatted.ods and streamtable.ods files, for example:

=file:///home/paolog/LIBPF_1.0/streamtable.ods'#\$Tabella1.\$A\$1

The {Libre,Open}Office INDEX(reference, row, column) function may be useful, as it allows you to switch from a row view to a column view.

By creating such connections, the formatted.ods file will remain permanently linked with the streamtable.ods file; at each new run you will be able to update the formatted.ods file in four steps:



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- Using the View → Results for streams in ODS format command in the LIBPF[™] user interface;
- Closing the this way rebuilt streamtable.ods file which will open automatically (examining or editing this file is not of interest);
- 3) Using the Edit \rightarrow Links command for formatted.ods in {Libre,Open}Office:



4) Clicking on the "Update" button and closing the dialog box:

File sorgente	Elemento:	Carattere	<u>S</u> tato	Chiudi
file:///streamtable.o	ıds	Documento	Manuale	<u>?</u> Aggiorna
				Modifica
File sorgente Elemento:	file:///home/paolog/LIB	PF_1.0/streamtable.ods		
Tipo: Aggiorna:	Documento	• Manua <u>l</u> e		

Exporting material and energy balances to Microsoft Excel

On supported Microsoft Windows operating systems, if the Microsoft Excel is installed, you can export all the material and energy balances for the material streams table by means of the *View* \rightarrow *Results for streams in XLS format* command:





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or with the corresponding button in the toolbar:



This command opens the streamtable.xls file in Microsoft Excel, and launches a macro written in Visual Basic for Applications which reads the needed values from the Microsoft Access database loading them in the "rawdata" sheet of the file.

The "formatted" sheet presents the same results properly formatted:



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×N	🗷 Microsoft Excel - streamtable.xls											
:2	Eile Modifica Visualizza Inserisci Formato Strumenti Dati Finestra ? Digitare una domanda. 🗸 🗗 🗙											
:		ABC	69 IV D				ALZIIA	a 🚮 1009/				
			BA 6 -3		-) • (- •	🍮 Z ▼	Z 🕈 A 🕈 🛄	100%	- 0 -			
Aria	al	• 10	• G C	s 🔳 🔳		3 🧐 %	000 50 500		🗄 • 🖄 •	A • 💂		
	U1	→ †	≨ =DESTRA	(rawdata!B	S1; LUNGH	EZZA(rawd	ata!BS1)-\$E	3\$1)				
	А	В	С	U	V	W	Х	Y	Z	AA	AB 🔨	
1				Gasifing MediumC old	Gasifing MediumH ot	RecycleC ondense	SyngasCl ean	SyngasC old	SyngasH ot	SyngasR aw	WasteN	
2		Aggiorna risultati		Gasifing medium cold	Gasifing medium hot	Condens e recycle to gasifier	Clean cold dry syngas	Cooled syngas from cooler	Hot syngas from tar cracker	Raw syngas de- dusted	Waste water conden ed fron syngas	
3		Procesure	bar	3.513	3.513	3.513	3.513	3.513	3.513	3.513	3.5	
4		Flessule	Atm	3.467	3.467	3.467	3.467	3.467	3.467	3.467	3.4	
5		Temperature	K	321.06	573.15	323.15	323.15	423.15	986.01	1008.04	323.1	
6		remperature	°C	47.9	300.0	50.0	50.0	150.0	712.9	734.9	50	
7		Mole weight	kg/kmol	27.7	27.7	18.0	21.6	21.4	21.4	21.6	18	
8		Mass flow	kg/h	106	106	6	190	201	201	201	L	
9		Mole flow	kmol/h	4	4	0	9	9	9	9	L	
10		1/-1	Nm3/n	85.8	85.8	1.1	196.5	210.7	210.7	208.5	<u> </u>	
10		Volume flow	m3/n	20.7	51.9	0.0	100.0	94.1	219.3	ZZ1.9		
12		Entrapy flow	KVV	-31.4	-19.0	-24.9	-190.9	-231.0	-101.0	-101.0	-24	
22	10	CO	W/K	-20.2	11.9	-10.2	00.0 EA	70.0 EA	143.0	142.0	-10	
22	gs	CO2	kg/h	0	0	0	04 17	04 47	54 47	23		
24	E .	H2	ka/h	0	0	0	41	41	41	40		
	¥ ↓	formatted / ra	awdata /		0			47	ر الا	40	······································	
Pront	to											

Beware to the displayed columns in the "formatted" sheet: it may be necessary to extend or reduce the number of those columns appropriately to handle flowsheet with more or less streams. If it is necessary to increase the number of formatted columns, select the last column to the right then click on the fill icon in the top-right corner then pull to the right; after that, remove the columns which display no stream name.

You can leave the Microsoft Excel window open and press the "Update results" button to re-run at any time (e.g. after a new calculation) the macro: this file will keep pointing to the object that was open in the LIBPF[™] user interface at the moment when the command of opening Excel has been given.

Exporting all data to a text file

It is possible to export all the data for the currently open object and all its sub-objects, saving them to a text file (.txt). This functionality is available in the "View" menu by clicking on "TXT results":





When this command is clicked, the current model (more precisely the node currently open in the tree view) is exported to a plain text file named "ID.txt" where ID is the model identifier in the database. The generated text file is automatically opened and displayed in the Operating System default application for opening text files (i.e. Notepad).

Exporting all data as XHTML

It is possible to export all the data for the currently open object and all its sub-objects, saving them in HTML format. This functionality is available in the "View" menu by clicking on "HTML results":



When this command is clicked, the current model (more precisely the node currently open in the tree view) is exported to a number of separate XML files, which are placed in a temporary directory together with a dozen auxiliary files.

The XHTML file named "index.xhtml" is automatically opened by the Operating System default application for opening HTML files (which must be one of the supported browsers), and from there it is possible to browse all sub-objects by following the links.



Sensitivity analysis

Very often in the course of a project sensitivity studies need to be performed. These sensitivity studies are very repetitive and only consist in changing one or more parameters (controlled variables) in a certain range for a certain number of points, by running a simulation for every point and recording in a table a certain number of results (monitored variables).

To automatize these tasks the LIBPF[™] user interface has a multi-dimensional sensitivity analysis feature. In practice this tool allows you to determine how sensitive a model is to the variation of the values of the parameters and assess how will the variation of the value influence the behavior of the model; it also provides assistance for the selection of the so-called "critical" variables, that is those whose deviation from the nominal value influences the performance indicators the most; with this tool you can acquire a lot of information about the model and the process in a short time.

The sensitivity analysis tool of the LIBPF[™] User Interface allows you to carry out several simulations by controlling one or more variables while maintaining all the other unchanged, and monitoring the effect on one or more results.

If you click on Tools \rightarrow Sensitivity analysis:



a window will appear with three tabs: "Control", "Monitor" and "Results":



Selec	t the variables to manip	ulate and their ranges	5	
	Controlled variables	: Units	Description	Label Start
- 1				0

On the "Control" tab it is possible to select one or more controlled variables (at least one is required), setting the units of measurement, the optional label to display in the results table ad column header, the start and end values for the range to scan and the number of points the range must be divided into. The table comes pre-filled with one row, it is possible to add additional controlled variables by clicking on the "+" at the bottom left. It is possible to remove a previously set controlled variable by clicking on the "-" button on the left side of each row.

In the lower part of the window it is possible to set the sensitivity execution order (natural, the default boustrophedon or quasi-spiral) and the maximum running time. The sensitivity execution order is important if there are some regions of the scanned domain where convergence is difficult. The maximum running time, if set to a value strictly greater than zero, is interpreted as a time-out expressed in seconds - if the sensitivity runs for so long, the run is interrupted and the results collected up to that point will be displayed.

The user can choose the controlled variable from the list of all the variables that can be specified for the current case (these are the variables that appear in the "Input" tab of the units and streams).

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As soon as one controlled variable has been chosen, or its selection has been changed, the program updates the units of measurement and initializes the start and end sensitivity limits with the current value of the variable; the description of the variable is also shown. The user must typically only change one of the two limits and probably set the number of points to a value greater than the default value equal to 1 that would reduce the sensitivity to the execution of a single run.

At this point you can press "Next" to proceed to the "Monitor" tab where you can choose the variables (results) to be monitored.

The user can choose the monitored variables from the list of all the results for the current case. As soon as a variable has been chosen, or its selection has been changed, the program updates the units of measurement, the description and the label of the variable. If desired, the user can change the label, which will be shown as a header in the corresponding column of the results table.

The table of monitored variables has a variable number of rows, however, greater than or equal to one (it does not make sense to follow a sensitivity study without monitoring at least one variable). The user can add new rows or remove the existing ones by using the plus (+) and minus (-) buttons.



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	ID	Monitored variables		Units	Description	Label
-	1		~			
		:FC.powerin :FC.powerMM :FC.purity_C02 :FC.recovery_C02 :FC.stacks :FC.system_conv :FC:COND.A :FC:COND.A	÷			

At this point you can click "Next" to proceed to the "Results" tab from which you can start the sensitivity analysis by clicking on the "Go" button; before doing so, form this dialog you can also save the configuration of the current sensitivity analysis by clicking on "Save" (see below, "Saving and loading sensitivity analyses").

Note that once arrived at the "Results" tab the two previous tabs are frozen, i.e. the settings for the controlled variable and for the monitored variables can no longer be changed. In fact, the "Edit sensitivity" button functions as a "back" button: unlocks the "Control" and "Monitor" tabs and allows you to change any settings.

If instead a sensitivity analysis is launched, the LIBPF[™] user interface starts the calculation kernel. During the execution the rows relative to each value of the controlled variable are highlighted while gradually proceeding to the calculation, and the results of the monitored variables are tabulated as soon as they become available. You can at any moment copy the table (by pressing the "Copy results to clipboard" button), stop (by pressing the "Stop" button) and resume (by pressing the "Go" button) the execution of the calculation.



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ID	bioIn [kg/s]	coolerP [Pa]	syngasLHV [J/kg]	Time [s]	Errors	Warnings	Iterations
	0,005						
	0,00511111						
	0,00522222						
	0,00533333						
	0,00544444						
	0,00555556						
	0,00566667						
	0,00577778						
	0,00588889						
0	0,006						
							0%

The rows are color coded highlighted according to the table:

Grey	Row in execution
Green	Row executed without warnings or errors.
Yellow	Row executed with warnings
Red	Row executed with errors (results are available, but probably not valid)
Dark Red	Row not executed because of a serious internal error of LIBPF™ (no results available)
Purple	Row not executed because of a LIBPF™ crash (no result available)
Dark cyan	The row is not completely executed because of an user break (no results available)



The table generated in this way can be copied to the clipboard (by pressing the "Copy results to clipboard") and from there into a spreadsheet.

Note: at the end of the sensitivity the interface substitutes the value assumed by the controlled variable in the last run in the appropriate Input box so that the loaded case results amended.

Saving and loading sensitivity analyses

If you click on the "Save" button on the Monitor tab once you have fully specified your sensitivity analysis, a small modal dialog appears:

	T	.SPECCA		specific	Primary Energy C
-	2	ւթ 💿	Save sensitivity and	alysis	🕑 🕙 ers
-	3	Enter sensitivity name:	theta new		arb
1 1	4	OK Cancel			ure
1	6	.Tmax	°C	Maximur	n stack temperat

where it is possible to enter a meaningful name for the sensitivity, up to 50 characters long, containing any character except the following reserved characters: < (less than) > (greater than) . (period) : (colon) " (double quote) / (forward slash) \ (backslash) | (vertical bar or pipe) ? (question mark) * (asterisk) _ (underscore), characters whose ASCII integer representations are in the range from 0 through 31 and \$ (dollar sign). If the supplied name has already been used to save a sensitivity for the current type, the user is asked for overwrite confirmation, else the sensitivity is saved to an XML file in the working folder, with a full name that contains both the sensitivity name and the current type name.

Saved sensitivity analyses can be loaded back using the "Open multi-dimensional sensitivity" dialog box that is available under the Tools menu:

🎦 🗁 🗁 🖬	
	Restore last run multi-dimensional sensitivity
Tag	들 Open multi-dimensional sensitivity
v− <mark>-</mark> -∰	💽 <u>S</u> ensitivity analysis



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The following dialog box appears:

		Type		nputs	Config	Outputs Messag	es PFD			
		ngfccc <mcfc,3,2></mcfc,3,2>			Tag	: Value :	Units			
100				1 SPEC	CCA	2,425320132		Spe		
ide sepa l	P 🔾	Open e	xisting multi-	dimensio	nal sensit	ivity study	0 0 0	🗵 🙁 🕹		
		Name	: Type				~	â Iqu		
		testoa	ngce					Tur		
	test6 ngcc							Tur		
ery steam		test3c ngcc								
itor	0									
for all sti I feed str	0	test3b	ngco	ngcc						
Divider	\bigcirc	test3a ngcc						Cur		
for all sti	\bigcirc	test3	ngco	:				Fra		
inteed su	0	one	ngco	ngcc						
	•	thetanew	ngfc	cc <mcfc< td=""><td></td><td></td><td></td><td></td></mcfc<>						
	0	thetal	ngfc	cc <mcfc,< td=""><td>3,2></td><td></td><td></td><td></td></mcfc,<>	3,2>					
	0	theta	ngfc	cc <mcfc< td=""><td>3,2></td><td></td><td></td><td></td></mcfc<>	3,2>					
	0	OK Cancel						-ra		
								-ra		
				16 fracs	SC	0,2847569394		Fra		

The dialog shows the list of available saved sensitivities along with their model types; the saved sensitivities whose type is equal to the type of the currently loaded case are highlighted in light blue. Typically it makes sense to retrieve a previously saved sensitivity for the same type as the current type, but advanced users can exploit the power of loading an existing sensitivity for a similar type, provided they know how to adapt it if required.

Settings

From the settings menu you can change some of the general settings of the application:





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 Swap children: toggles the viewing in the details view panel of the input variables and of the results of the objects in the currently selected object in the tree view; for example if the currently selected object is the deltaT flowsheet, and the viewing of the "children" is disabled, the interface could look like this:

Etiche	tta			Descrizione	Tipo	In	put	Configurazion	Risultati	Messaggi PFD	
4 🕸	tes	st		calcolo del delta T adi	DeltaT			Etichetta	Valore	Unità di misura	[
1	2	Str	eams			1	:cd	uty	0	m^2 kg s^-3	Cumulative entha
	⊳	•	S01	Fuel	StreamIdealLiquidSoli			dot	0	ka c∆-1	Cumulative mass
	\triangleright	•	S02	Oxidant	StreamIdealLiquidVapor	2		luot	•	ky 5 -1	Cumulative mass
	\triangleright	•	S03	Flue gases	StreamIdealSolidVapor	3	:ma	axAdiabaticC	2311,021378	К	adiabatic combus
4		Un	its								
	\triangleright	\boxtimes	RX	Reactor	FlashDrum						
		\boxtimes	sink	Destination for all stre	Terminator						
		\boxtimes	source	Source of all feed strea	Terminator						
								"	1		F.

if instead the viewing of "children" is activated, the interface could look like this:



Cumulative

Cumulative

adiabatic co

Cumulative

Cumulative

Pressure drc

Entropy pov

Duty inlet -

Pressure

ssaggi PFD

m^2 kg s^-3 kg s^-1

m^2 kg s^-3

m^-1 kg s^-2

m^2 kg s^-3

m^-1 kg s^-2

m^2 kg K^-1 s...

kg s^-1

К

Unità di misura

Eti	ichet	ta			Descrizione	Tipo	Input		Configurazione	Risultati	Me
4	-8	🗿 test			calcolo del delta T adi	DeltaT			Etichetta	Valore	
4	⊿		Str	eams	Fuel Strear Oxidant Strear Flue gases Strear		1		cduty	0	
		\triangleright	•	S01		StreamIdealLiquidSoli	2		:cmdot	0 2311,021378	
		\triangleright	•	> S02 > S03		StreamIdealLiquidVapor StreamIdealSolidVapor FlashDrum Terminator . Terminator	3				
		\triangleright	⇒						:maxAdiabaticC		
	⊿		Un	its			4		aT:RX:cduty	-2,38418579	1e-07
		\triangleright	\boxtimes	RX	Reactor Destination for all stre Source of all feed strea		5 6		aT:RX:cmdot	6 117200040- 0	0- 07
			\boxtimes	sink						-0,117390949e-0	
				source					aT:RX:deltaP	0	
							7		aT:RX:deltas	2686,749674	
							8		aT:RX:duty	0	
							9		aT:RX:P	101325	
								III			

note how in the details view panel the results of the internal objects of the flowsheet have appeared, recognizable because the label contains the complete path to them (e.g. RX:P is the pressure of the RX unit);

- Select the kernel: if more calculation kernels have been installed (each of which can simulate various components and processes) this command allows you to switch from one kernel to another; note: this feature is only available on Windows systems;
- Activate: allows you to start the automatic activation procedure (see the LIBPF_USR_activation);
- Language selection: from here you can change the language of the user interface (the default is set to the language of the operating system); note: the language selection is only effective after restarting the LIBPF[™] user interface.