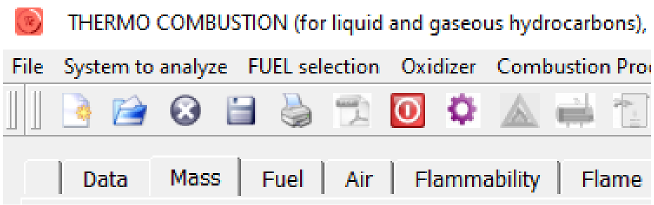
ThermoCombustion
Hidrocarbon Fuels Edition

f SéNeCa(+)
Agencia de Ciencia y Tecnología
Región de Murcia

THERMO COMBUSTION | Technical & Educational Software



Software developed for combustion processes' characterization. Major application to industrial combustion processes, such as combustion heat or electricity generation processes; whether they take place in steam generators, gas turbines or stationary engines, and in industrial furnaces (with or without fire contact).

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Characteristics

- **Solid technology**
- **Precision**
- **Easy handling**
- **Intuitive interface**
- **Input variability**
- **Application in several industrial systems**

Software capabilities

- Thermo-chemical analysis
- Mass, energy and exergetic balance
- Energetic flow and *Grassmann* diagram
- Thermal and exergetic efficiency
- Combustion diagrams
- Sensitivity analysis
- Pollutant emissions control

Applications

Improvement of combustion process design, comprehensive study of main variables effect in the combustion, whether reducing irreversibilities or pollutant emissions; or performing several sensitivity analysis that ***Thermocombustion*** facilitates by default.

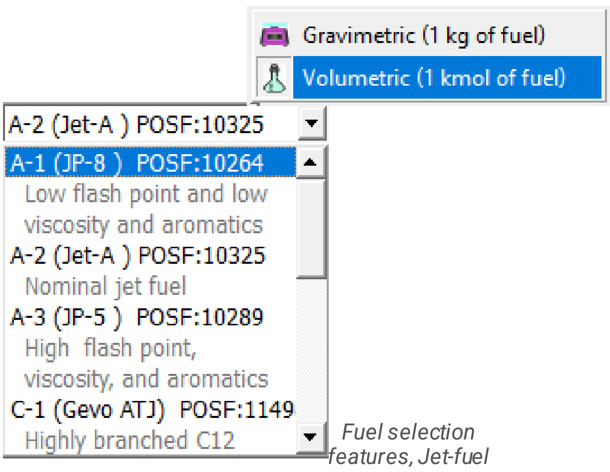
Main application in industry for process optimization or in academia (technical studios).

Characteristics

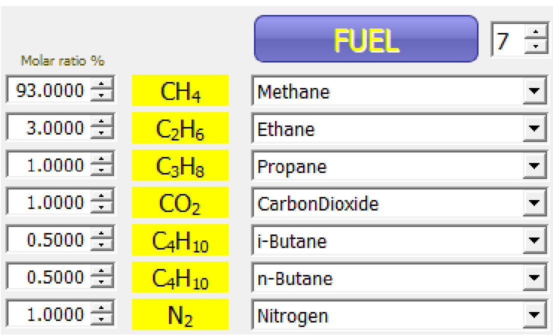
Software algorithms are based on up-to-date bibliography and the latest mathematical models, which in conjunction result in a **well-defined** and **solid technology**. The software has been set up with an **intuitive interface** that allows **easy handling**.

Input variability

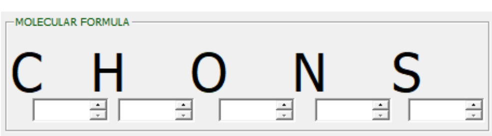
The user can choose the **composition**: mixture of hydrocarbons, aviation fuel, by empirical formula, etc.



Fuel selection features, Jet-fuel



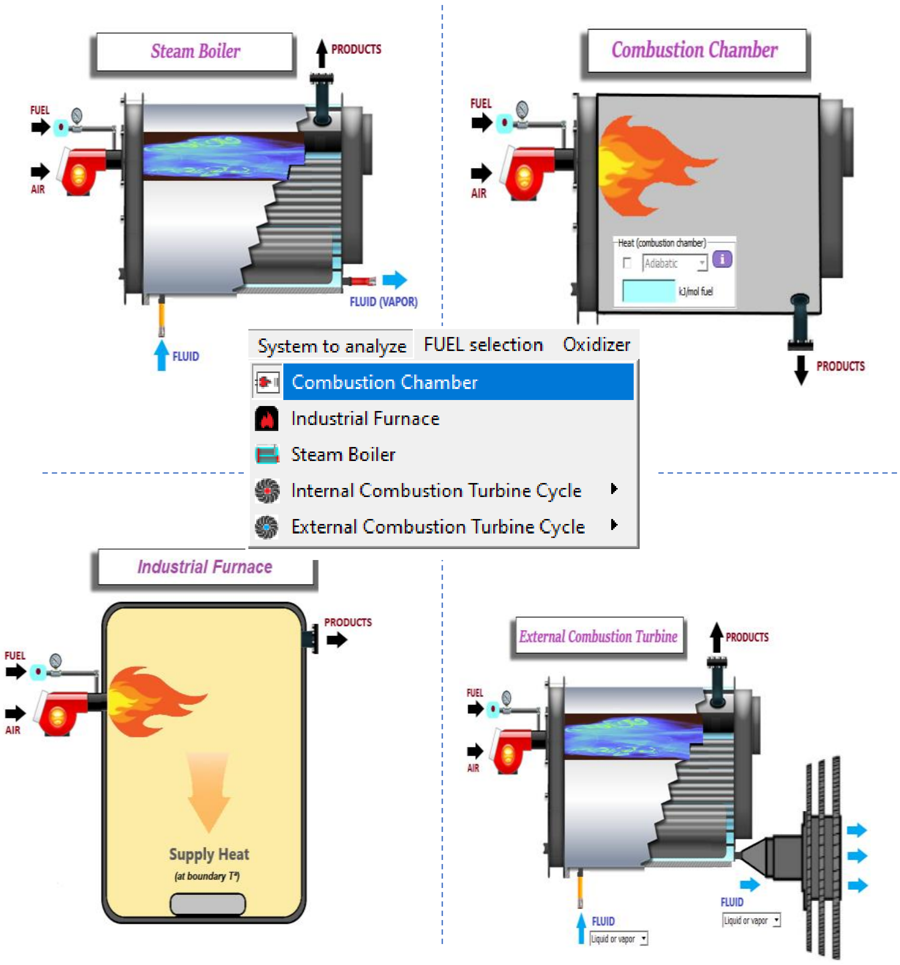
Fuel selection features, Natural gas



Fuel selection features, Molecular formula

Application in several industrial systems

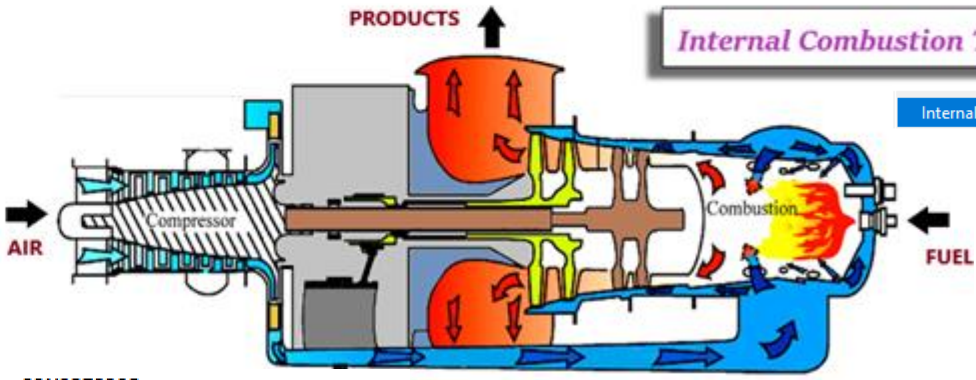
Combustion chamber, industrial furnace, steam boiler or combustion turbine (internal or external).

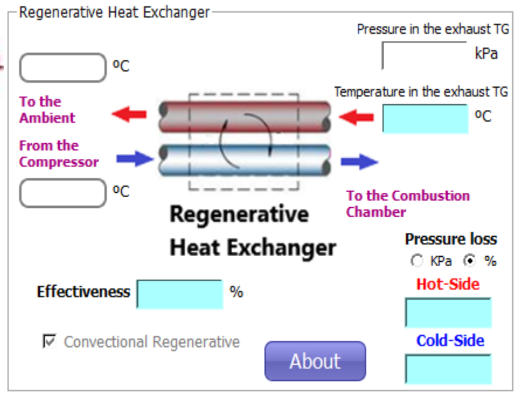


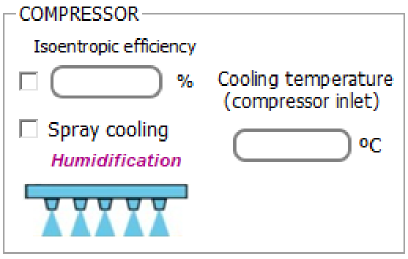
Industrial combustion systems available to analyse

Internal Combustion Turbine Cycle

Gas turbine cycles can be studied. There are essentially two types of gas turbine cycles. The simple cycle, where the gas is exhausted directly to atmosphere. The regenerative cycle, where the exhaust gas is used in an exchanger (regenerator) to preheat the compressor discharge air prior to the combustor.





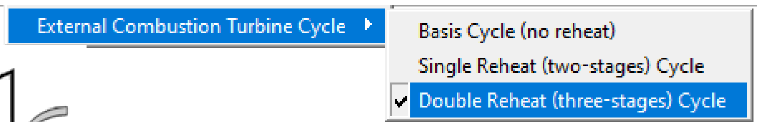


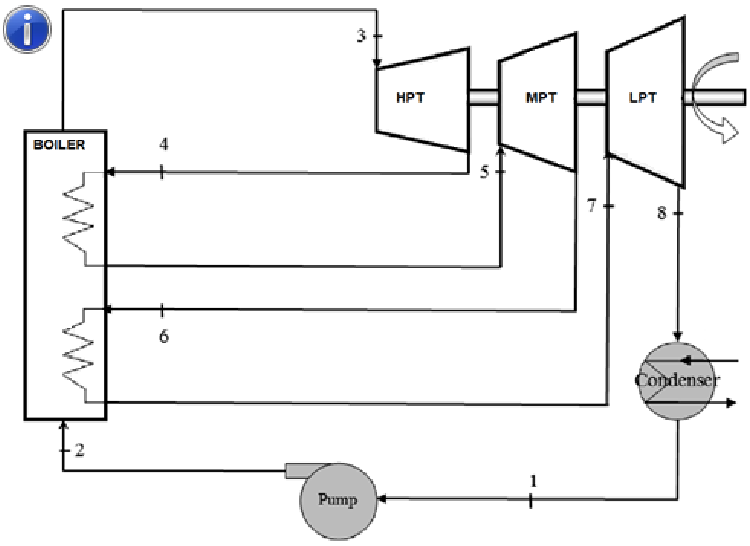
Regenerative cycle

Gas turbines intercooled by water spray injection systems have recently entered service. ThermoCombustion permits to study this effect to be evaluated and compared with conventional cooling techniques for a range of cycles.

External Combustion Turbine Cycle

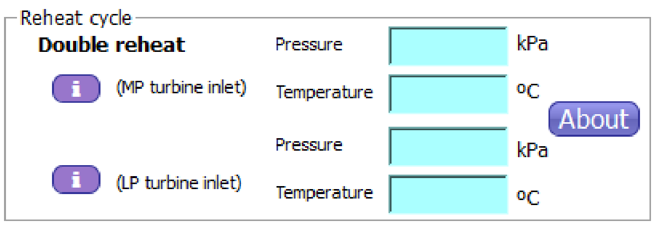
Steam turbines are external combustion. They don't have a compressor like a gas turbine has, instead, water is boiled in a separate boiler (external to the turbine) and then fed to the turbine where it pushes against the turbine blades and spins them.





Reheat cycle (double reheat)

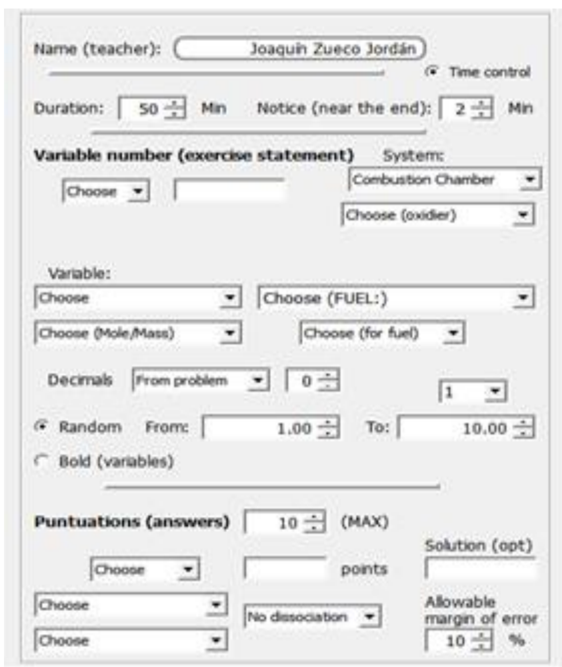
The advances in steam pressure and temperature led to the development of the reheat cycle, where steam is exhausted from the high-pressure turbine at reduced pressure and temperature and is then returned either to a section of the boiler or to a separate boiler to be reheated.



Teaching activity (Not available in industrial version)

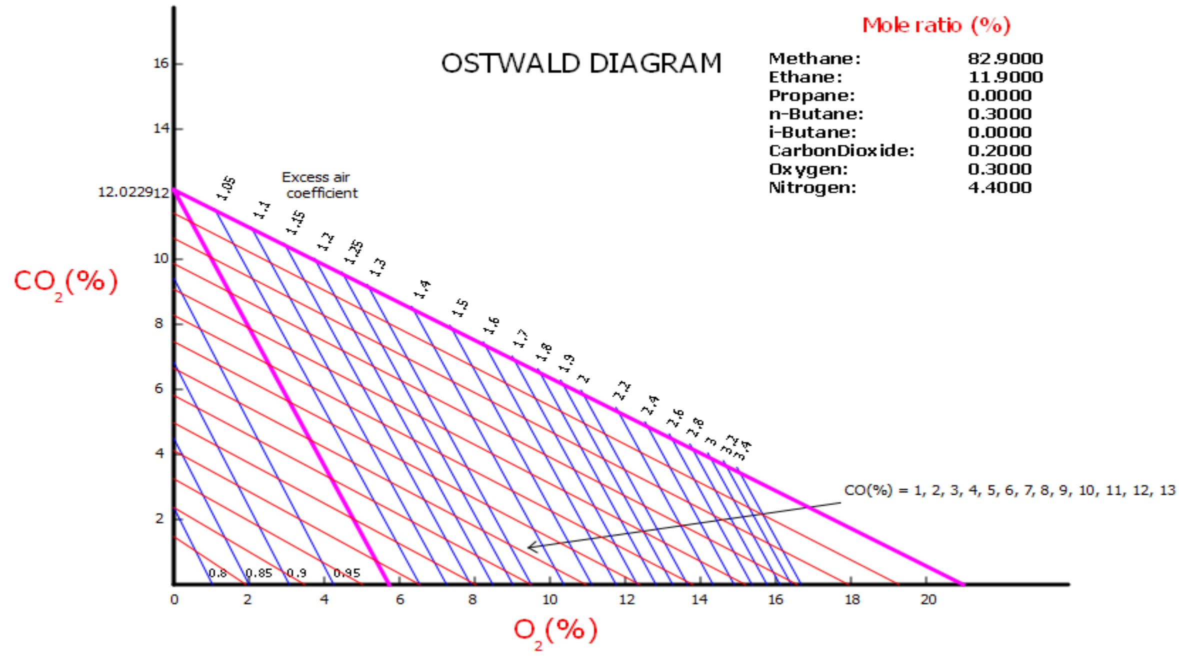
The teacher can design a teaching activity that the student will solve using the software and the score obtained by the student, results and student responses are generated immediately in a pdf file no-editable.

This activity is very attractive for the learning-teaching process in technical studies, both for the teacher and for the student, since it allows to solve the exercises and/or design projects in an efficient and fast way, and the knowledge of the qualification obtained by the student is immediate.

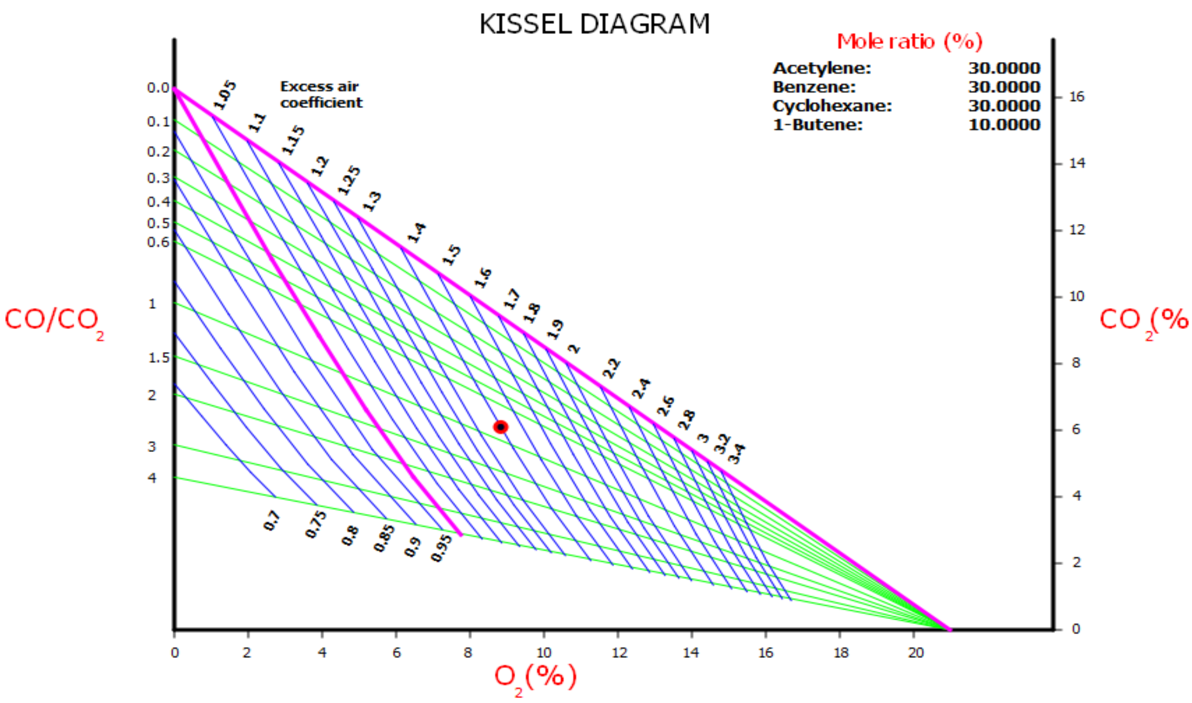


Combustion charts

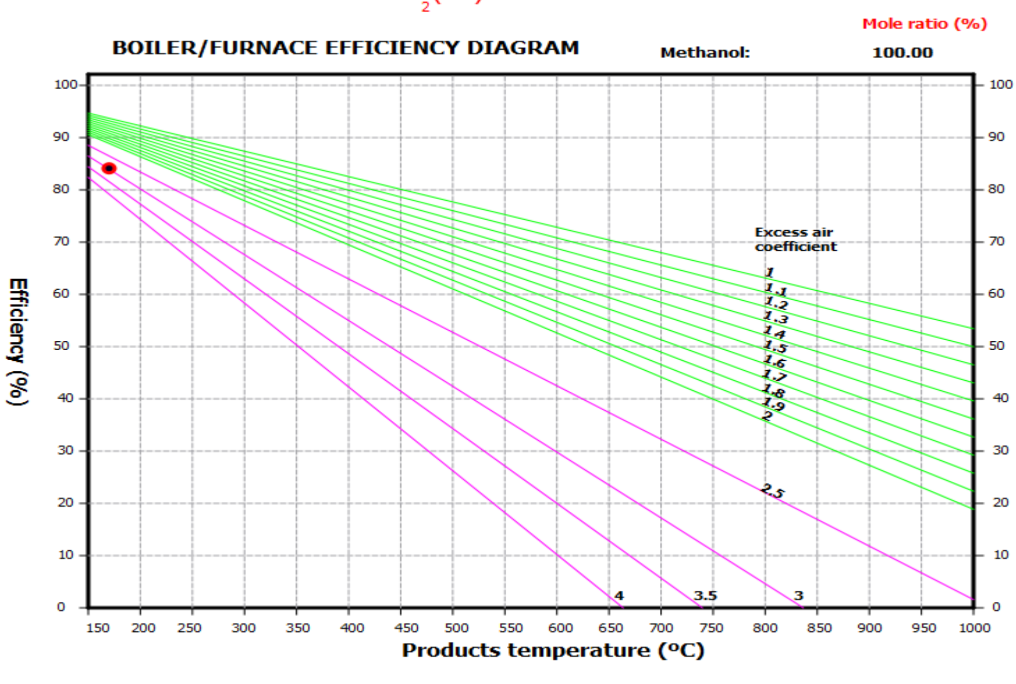
Ostwald, Grebbel, Bunte and ***Kissel*** combustion diagrams allow fast and accurate combustion calculations. In order to get an analysis closer to reality, it is possible to work in '**dissociation' mode**; it facilitates the combination of the most common chemical reactions in this processes.
Combustion processes are characterized by the presence of unburned, these substances are generally carbon such as soot, CO, H2 and small amounts of hydrocarbons used as fuels may also appear.



In the case of the combustion reaction in which only CO is produced in the combustion gases, it is known It is a graphical representation of a combustion process, for a specific fuel. Once the diagram for that fuel has been developed, through a smoke analysis, knowing the percentage of one of the three elements represented (%CO2, %CO or %O2) and knowing the excess air, we can know the composition of the rest of the exhaust gases.



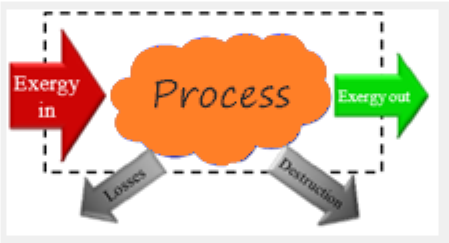
In the case of the combustion reaction in produces CO and H2 is known as Kissel Combustion. These denominations derive from the use of the diagrams of these authors used to determine the respective combustion reactions, being evident that the Ostwald reaction is a particular case of the Kissel reaction.



The performance will increase as the smoke temperature decreases, and the percentage of CO2 in the combustion products increases. But the increase in CO2 can lead to an uncontrolled increase in dangerous CO with problems for the boiler home and especially for the safety of people.

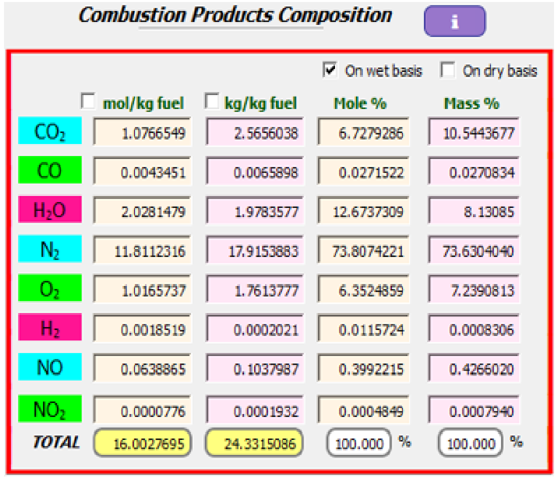
Thermo-chemical analysis

As a first step, a **mass balance** of combustion products can be obtained. Strict analysis on whole range of **fuel properties**: calorific powers, specific heat, enthalpy of formation, chemical exergy, entropy, including the flammability diagram.



Exergy analysis

From second law evaluations (entropy or exergy evaluations) it is generally known that thermodynamic losses of boilers and furnaces are much higher than the thermal efficiencies do suggest.



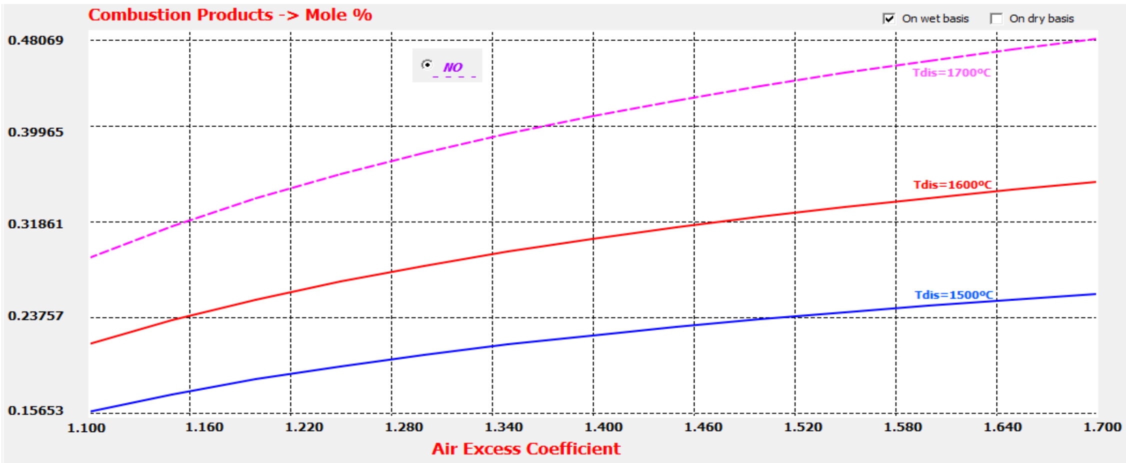
Combustion Products Composition (On wet basis)

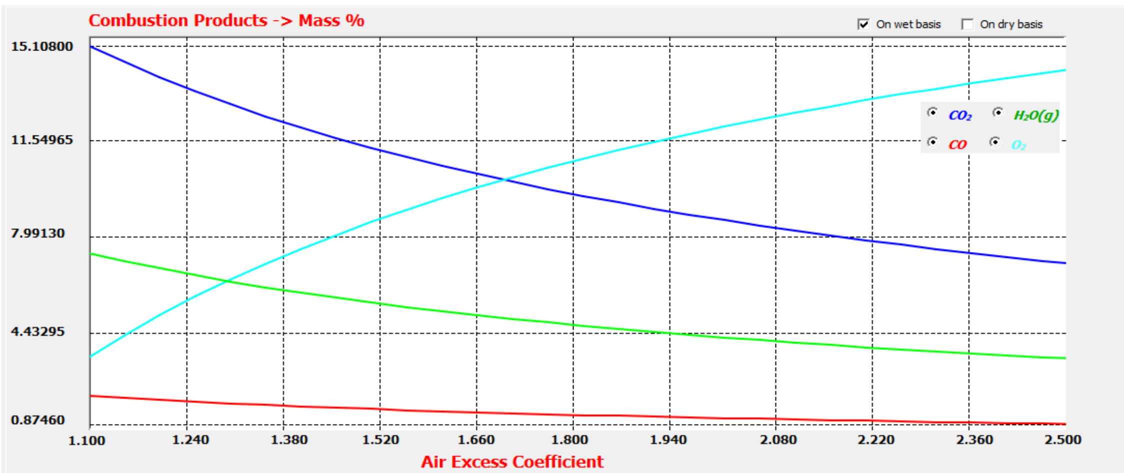
	mol/kg fuel	kg/kg fuel	Mole %	Mass %
CO_2	1.0766549	2.5656038	6.7279286	10.5443677
CO	0.0043451	0.0065898	0.0271522	0.0270834
H_2O	2.0281479	1.9783577	12.6737309	8.13085
N_2	11.8112316	17.9153883	73.8074221	73.6304040
O_2	1.0165737	1.7613777	6.3524859	7.2390813
H_2	0.0018519	0.0002021	0.0115724	0.0008306
NO	0.0638865	0.1037987	0.3992215	0.4266020
NO_2	0.0000776	0.0001932	0.0004849	0.0007940
TOTAL	16.0027695	24.3315086	100.000 %	100.000 %

Mass balance interface

Sensitivity analysis

Analysis of main variables involved in the combustion processes' study. Graphical display of main results, energy balance, mass balance, pollutants, temperatures, efficiencies, exergy balance, etc



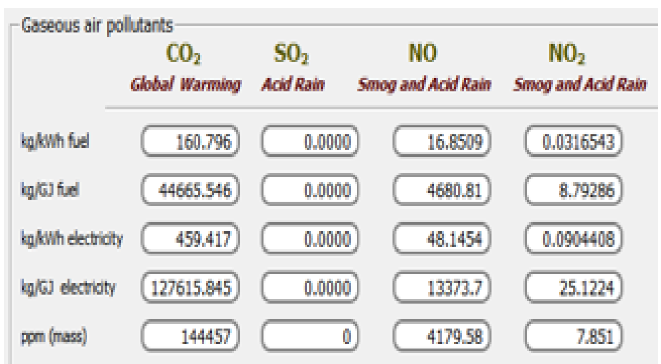


Graphic representations of sensitivity analysis

Pollutant emissions control / Sulfuric acid dew point *

Includes critical pollutants as carbon monoxide (**CO**), nitrogen oxides (**NO, NO_2, N_2O y N_2O_4**) and sulfur dioxide (**SO_2**) among others.

To prevent sulfuric acid condensation problems in industrial facilities that burn fuels with the presence of sulfur, it is necessary to know the dew point temperature of the sulfuric acid. An exhaustive analysis of the chemical reactions involved until reaching the formation of sulfuric acid is carried out.



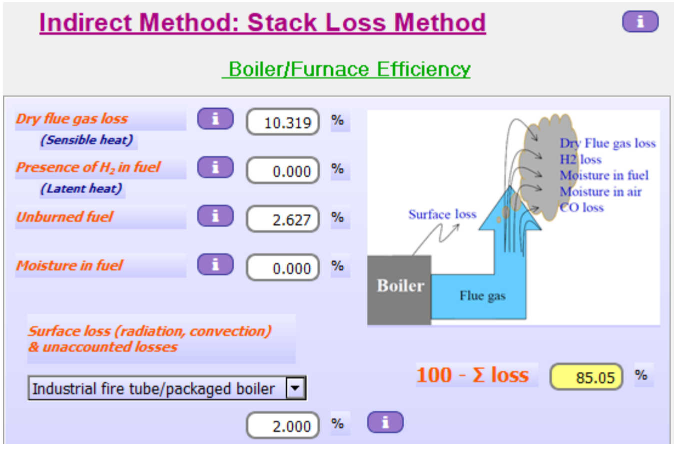
Gaseous air pollutants

	CO_2 Global Warming	SO_2 Acid Rain	NO Smog and Acid Rain	NO_2 Smog and Acid Rain
kg/kWh fuel	160.796	0.0000	16.8509	0.0316543
kg/GJ fuel	44665.546	0.0000	4680.81	8.79286
kg/kWh electricity	459.417	0.0000	48.1454	0.0904408
kg/GJ electricity	127615.845	0.0000	13373.7	25.1224
ppm (mass)	144457	0	4179.58	7.851

Pollutant emissions

Energetic analysis

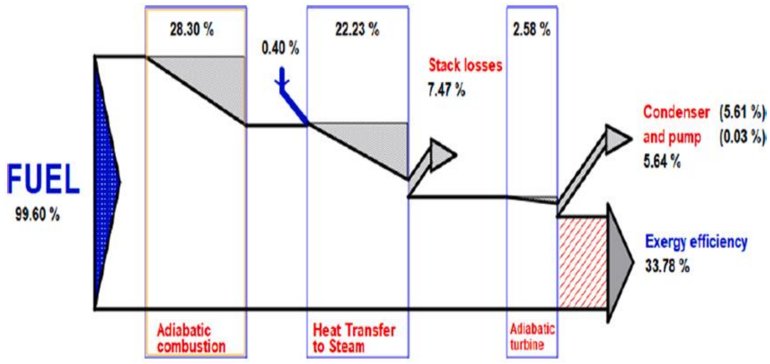
Includes flow diagram with **energetic efficiency** obtained by different methods.



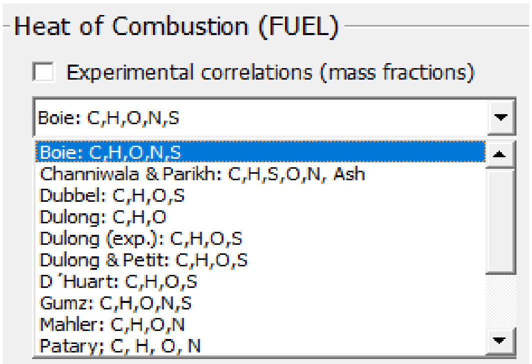
Energetic analysis interface by indirect method

Exergy analysis

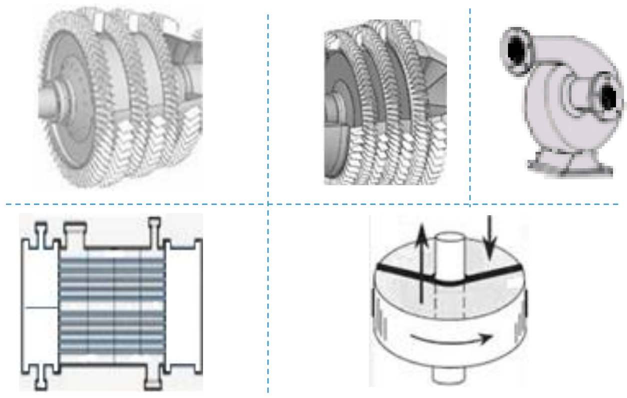
Based on Second Principle, it provides information about **irreversibilities** generated in each device of the installation, including the internal of the combustion process.



Results visualization using a Grassmann combustion diagram



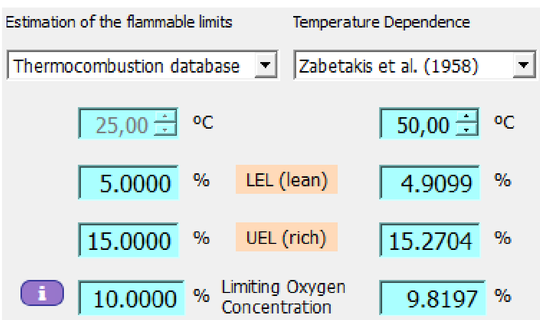
Heat of combustion of the fuel by means of experimental correlations

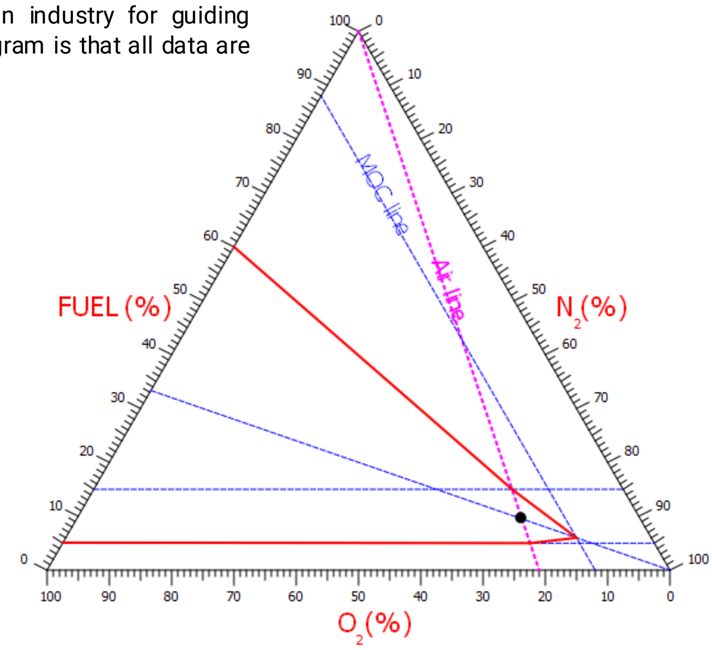


Devices

Flammability *

A ternary flammability diagram gained a popular position in industry for guiding dilution and purge operations. The advantage of a ternary diagram is that all data are directly readable and oxygen enriched atmosphere is allowed.

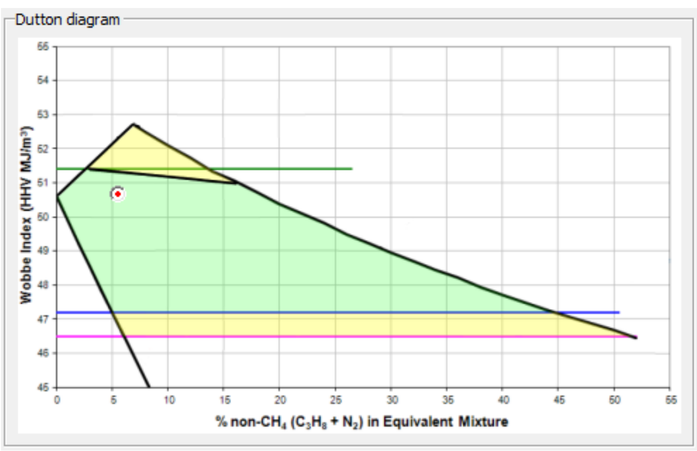


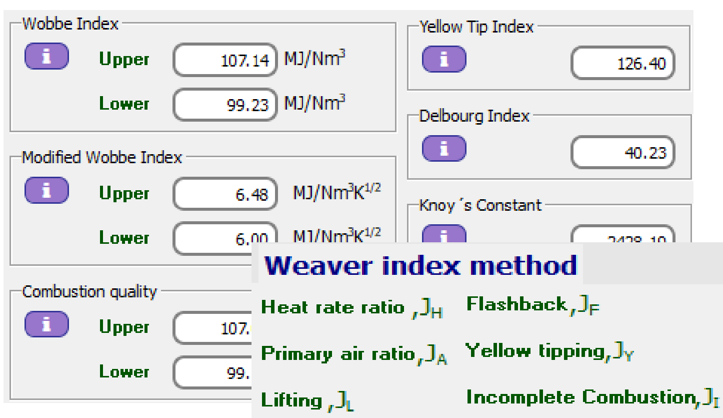


Ternary flammability diagram

Interchangeability of gaseous *

Fuel gas: availability to predict **interchangeability** of a fuel gas for another gas or a gas mixture. Use of Dutton method, *Yellow Tip*, *Wobbe index*, *AGA* and *Weaver* indexes and others.





Interchangeability analysis interface on fuel gas

Applications

In summary, ***Thermocombustion*** provides a complete solution of combustion processes; analysing the effect of the main variables that participate in the process, through the possibility of performing a graphical sensitivity analysis.

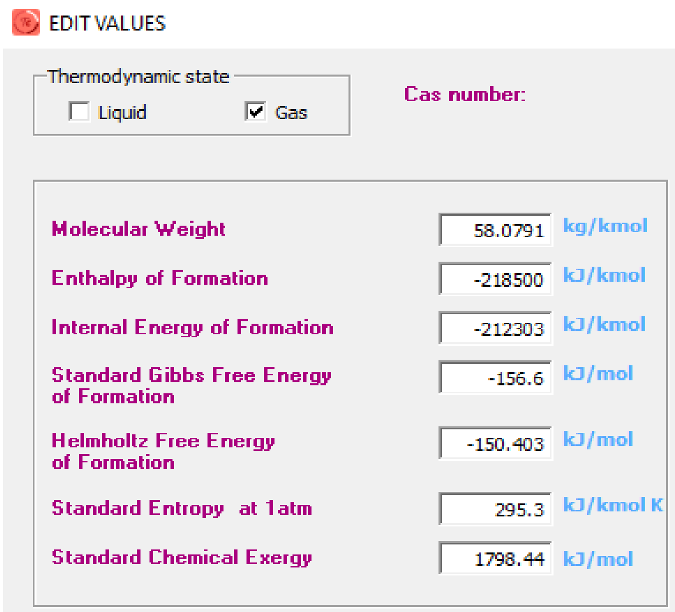
Whole range of software capabilities facilitates an improvement in combustion process design, an exhaustive study of main variables effects, and the possibility to reduce irreversibilities or pollutant emissions. A final report (set up by the user) can be submitted, containing graphs and predictions.

Major application for process optimization in **industry** or combustion processes study in **academia**.

Application specifications

This software's capabilities are appropriate for combustion studies in academia. The features explained above are highly useful; however, some additional ones should be taken into consideration. ***Thermocombustion*** include an **integrated database** with thermo-physic properties annotated from a wide range of chemical compounds. Moreover, a prediction of **thermodynamic properties** of combustion products and **equilibrium composition** can be obtained.

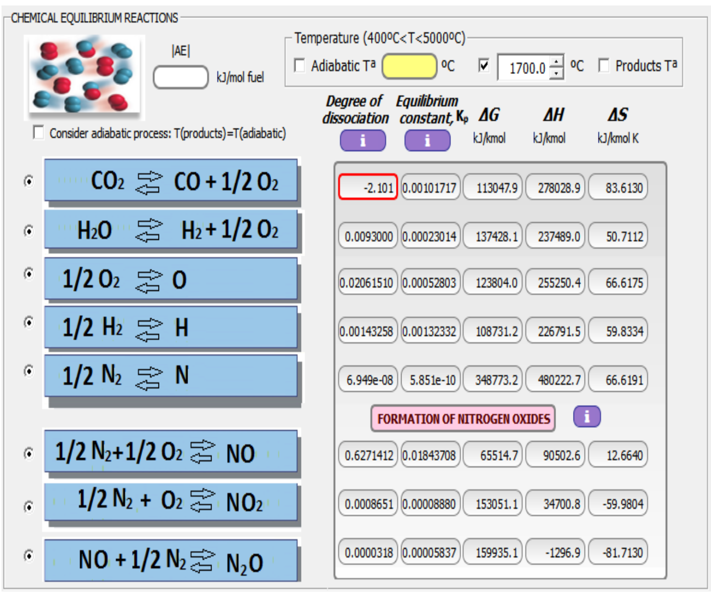
An **integrated database** on software with more than 100 (for industrial version) chemical compounds with thermo-physic properties annotated. Available to **combine at least 25 compounds as an input mixture** to analyse.



Thermodynamic properties annotated on software database for methane

** For industrial version only* Industry version

Theoretical determination of the **equilibrium composition** and **thermodynamic properties** of combustion products, related to temperature and pressure, as well as the dosage used or the fuel gas mixture, according to chemical balance and dissociation.



Composition analysis of combustion products on chemical equilibrium

ThermoSuite Technical Software Suite

For product-related and techical questions:

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