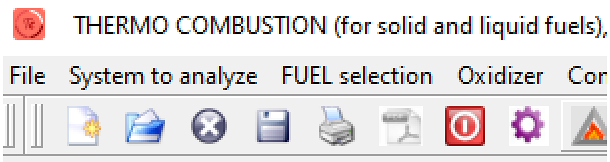
ThermoCombustion
Biomass & Biodiesel

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.

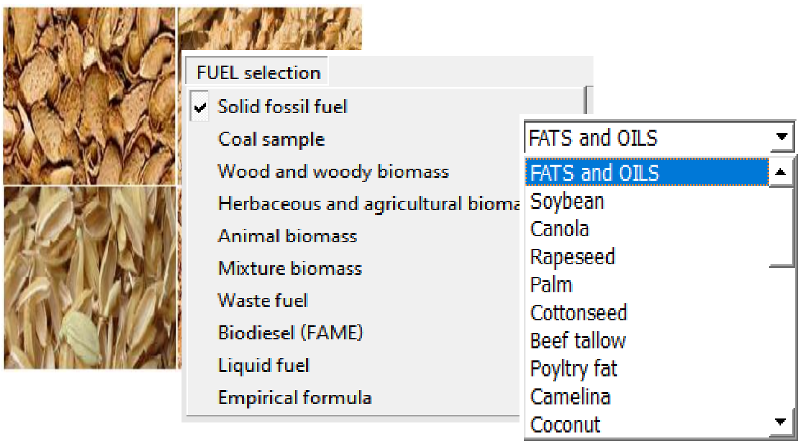
Main application in industry for process optimization or in academia (technical studios).

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

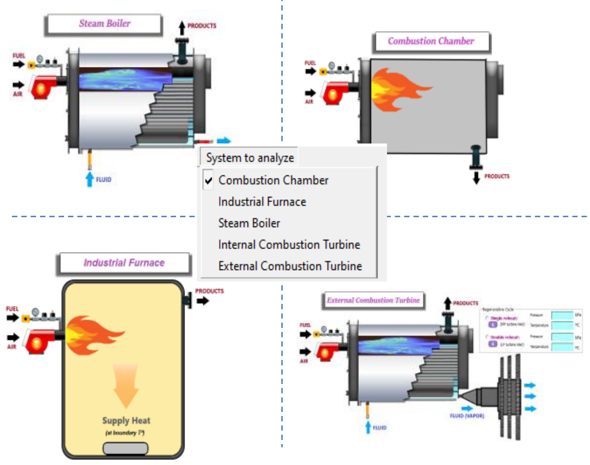
Available calculations with solid (including coals, biomass and biodiesel) and liquid fuel.



Fuel selection features

Application in several industrial systems

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

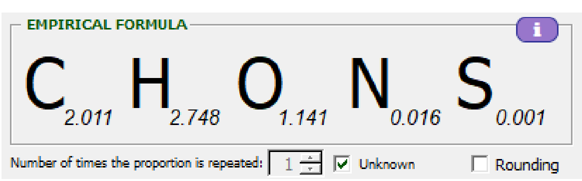


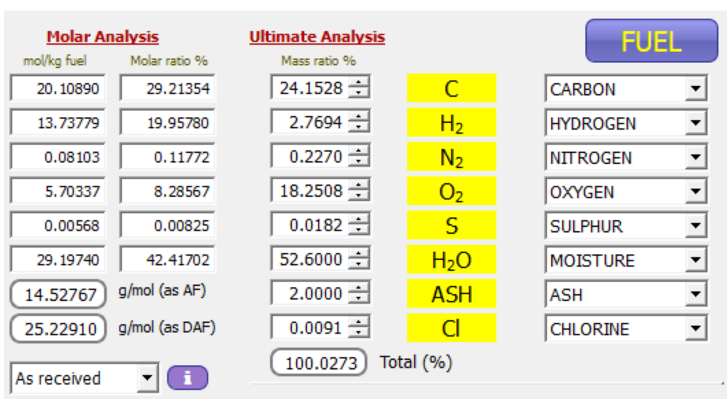
Industrial combustion systems available to analyse

Software capabilities

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 and entropy.

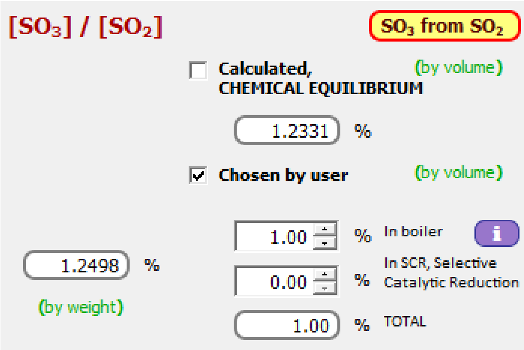


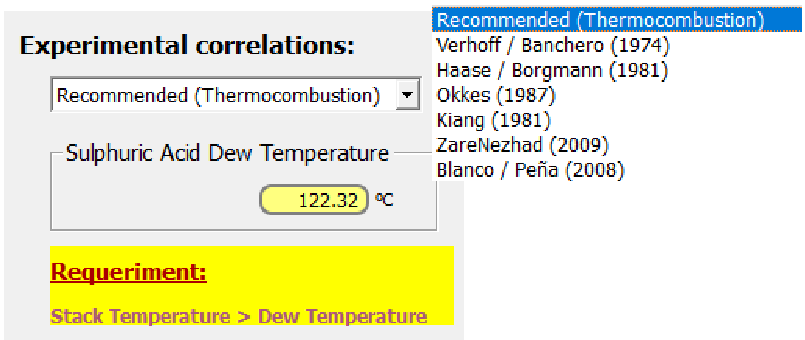


Composition of the fuel (ultimate analysis)

Sulphuric Acid Dew Point

When flue gas reaches a temperature below the acid dew point, acidic elements will condense. This could cause heat exchanger corrosion. Knowing the acid dew point of your flue gas enables you to select the appropriate materials for your heat recovery installation. Most of the solid fuels contain sulphur, which get readily converted to SO_x in the combustion chamber. Mainly SO_2 is formed, but part of this SO_2 (about 2-4%) oxidizes further to SO_3. The formed SO_3 subsequently reacts with H_2O to form sulphuric acid, when the flue gas cools below the Acid Dew Point. The sulphuric acid is highly corrosive and affects susceptible equipment surfaces.

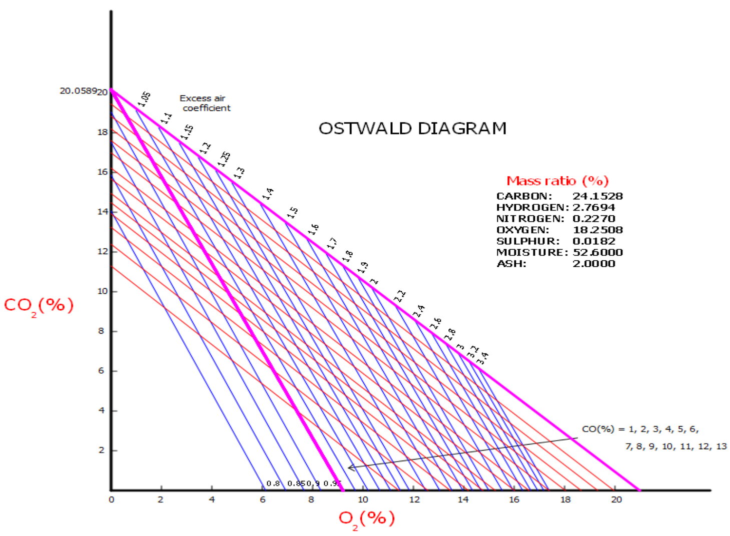




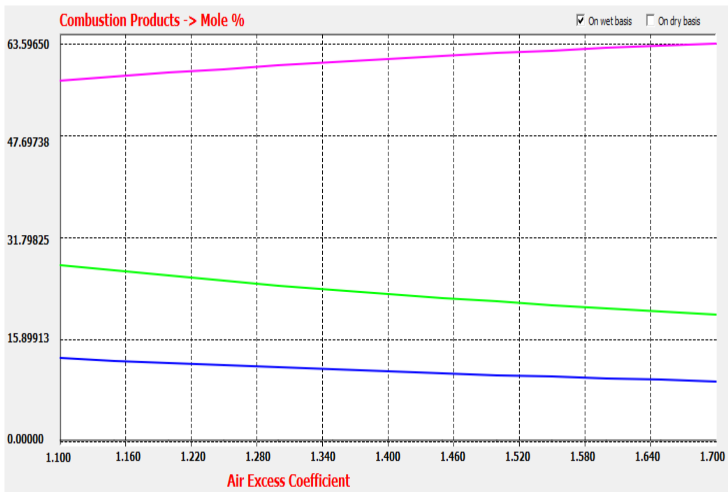
Sensitivity analysis

Analysis of main variables involved in the combustion processes' study. Graphical display of results and calculation of Ostwald and Kissel combustion diagrams.

Ostwald and ***Kissel*** combustion diagrams allow fast and accurate combustion calculations.



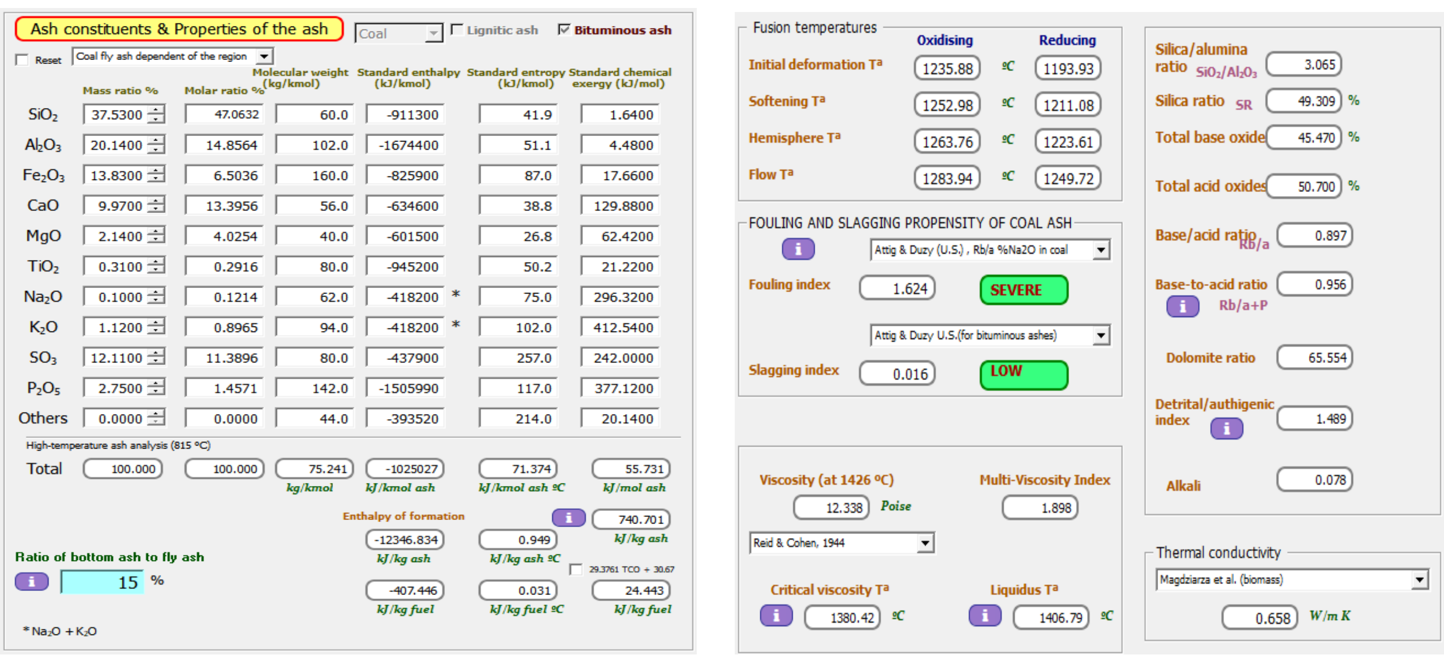
Ostwald diagram



Graphic representations of sensitivity analysis

ASH

Solid fuel: exhaustive thermodynamic study related to the **composition of ashes**: molecular weight, enthalpy of formation, entropy, exergy, melting temperatures and fouling tendency among others.



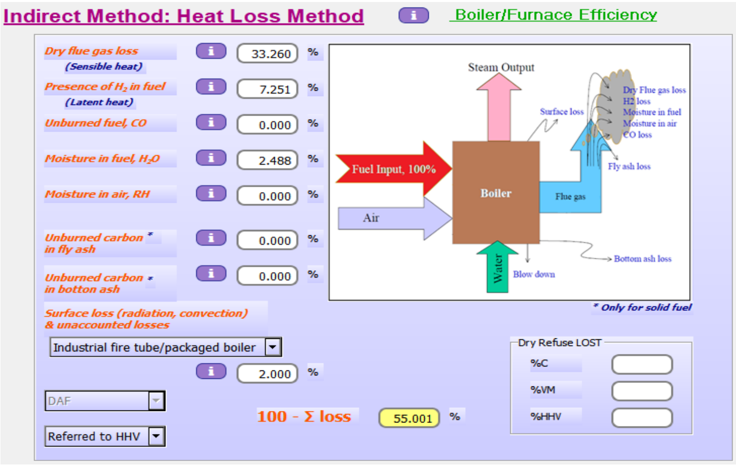
Ash constituents & Properties of the ash

	Mass ratio %	Molar ratio %	Molecular weight (kg/kmol)	Standard enthalpy (kJ/kmol)	Standard entropy (kJ/kmol)	Standard chemical exergy (kJ/mol)
SiO_2	37.5300	47.0632	60.0	-911300	41.9	1.6400
Al_2O_3	20.1400	14.8564	102.0	-1674400	51.1	4.4800
Fe_2O_3	13.8300	6.5036	160.0	-825900	87.0	17.6600
CaO	9.9700	13.3956	56.0	-634600	38.8	129.8800
MgO	2.1400	4.0254	40.0	-601500	26.8	62.4200
TiO_2	0.3100	0.2916	80.0	-945200	50.2	21.2200
Na_2O	0.1000	0.1214	62.0	-418200 *	75.0	296.3200
K_2O	1.1200	0.8965	94.0	-418200 *	102.0	412.5400
SO_3	12.1100	11.3896	80.0	-437900	257.0	242.0000
P_2O_5	2.7500	1.4571	142.0	-1505990	117.0	377.1200
Others	0.0000	0.0000	44.0	-393520	214.0	20.1400
Total	100.000	100.000	75.241 kg/kmol	-1025027 kJ/kmol ash	71.374 kJ/kmol ash ºC	55.731 kJ/mol ash

Thermodynamic study interface on ashes

Energetic analysis

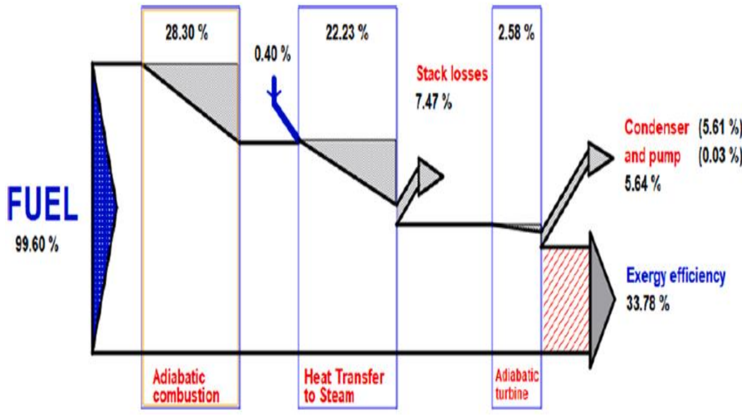
Includes flow diagram with **energetic efficiency** obtained by different methods, including indirect method on solid fuel.



Energetic analysis interface by indirect method

Exergy analysis

Based on Second Principle, it provides information about **irreversibilities** generated in combustion process. The combustion process is responsible for a significant part of these losses.



Results visualization using a Grassmann combustion diagram

Energy, Entropy, Exergy and Gibbs analysis

The results of the analysis of energy and availability balance show that the first and second laws efficiency for biomass, carbon and biodiesel fuel are useful tools to obtain the total availability, indicated work availability, the heat loss availability, burned fuel availability, other irreversibilities, etc.

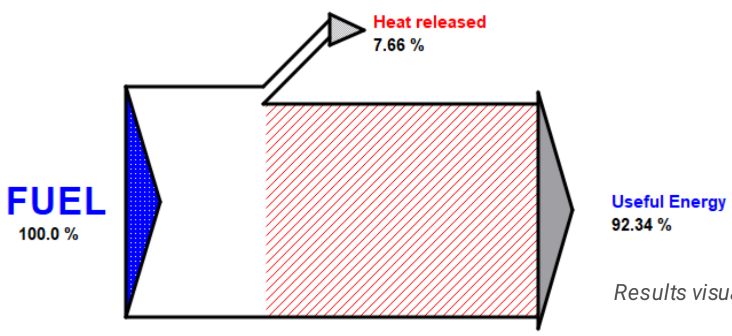
ENERGY BALANCE: FLUE GAS

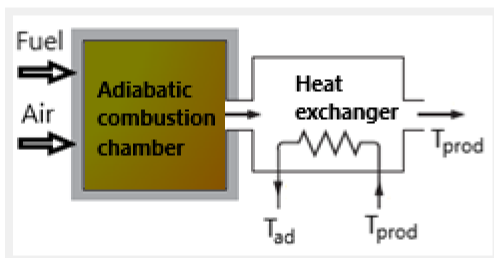
	kJ/mol	kJ/kg fuel
CO_2	-360.1150	-7241.5278
CO	0.0000	0.0000
H_2O	-215.8420	-9266.9404
O_2	22.7070	289.9259
N_2	21.4600	2750.4668
H_2	0.0000	0.0000
SO_2	-262.7260	-1.4923
HCl	-88.1093	-0.2176
Ar	0.0000	0.0000
TOTAL	-882.6253	-13469.7861

ENTROPY BALANCE: FLUE GAS

Entropy balance
Exergy balance
Gibbs function

	kJ/mol K	J/mol fuel K
CO_2	288.5716	346.2859
CO	262.9121	105.1648
H_2O	253.4695	253.4695
O_2	273.3625	92.3957
N_2	230.5037	2114.0701
H_2	0.0000	0.0000
SO_2	316.7540	63.3508
Ar	0.0000	0.0000
He	316.7540	63.3508
unburned	0.0000	0.0000
TOTAL	1625.5732	2974.7368





Results visualization using a Sankey combustion diagram

Pollutant emissions control

Includes critical pollutants as carbon monoxide (**CO**), nitrogen oxides (**NO, NO_2**) or sulfur dioxide (**SO_2**), ash, among others.
To reduce the amount of hazardous air pollutants emitted by commercial and industrial boilers, it is necessary to know exactly and completely the behavior of a certain fuel when it is subjected to a reactive process, in order to act effectively through a control mechanism.
For example, while replacing a significant amount of coal with wood would reduce sulfur emissions, the effect on other pollutants is not straightforward.

Gaseous air pollutants

CO_2 *Global Warming*	SO_2 *Acid Rain*	NO *Smog and Acid Rain*
NO_2 *Smog and Acid Rain*	N_2O *Global Warming*	N_2O_4 *Smog and Acid Rain*
CO *Health Effects*	Particulate matter, fly ash *Smog*	

Pollutant emissions

Applications

In summary, ***Thermocombustion (for biomass and biodiesel)*** 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.

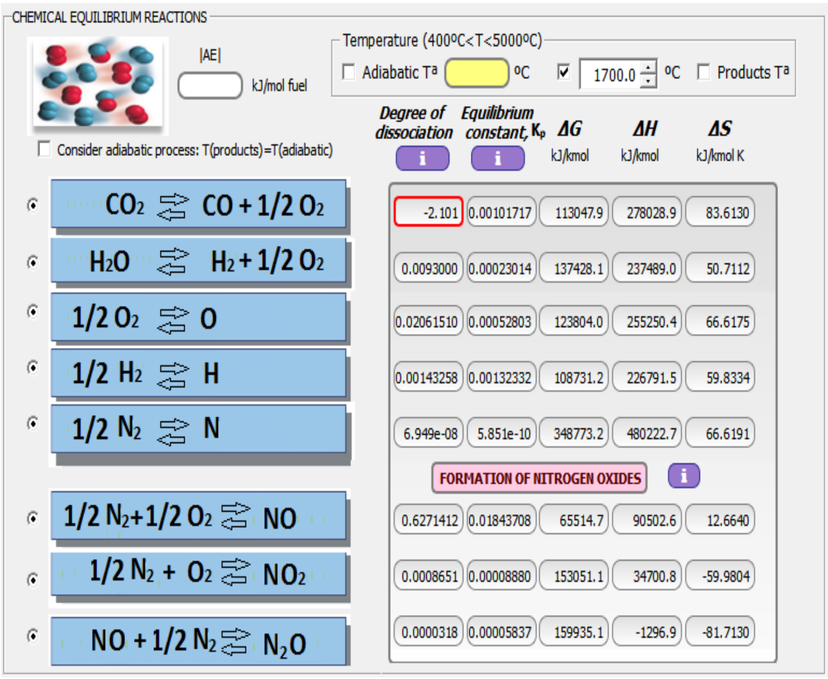
Whole range of software capabilities facilitates an improvement in combustion process design, an exhaustive study of main variables effects, and the possibility to reduce irreversibilities or pollutant emissions. A final report (set up by the user) can be submitted, containing graphs and predictions.

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

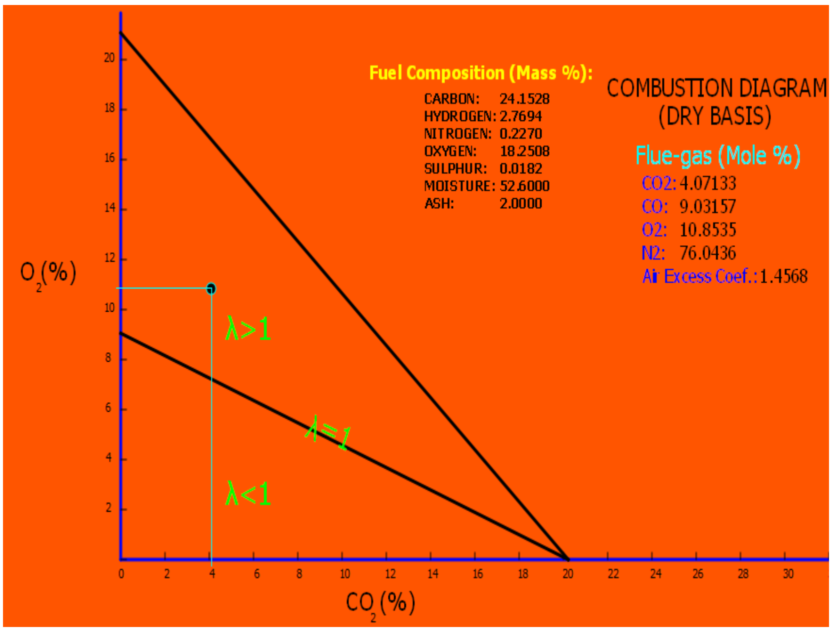
Application specifications

This software's capabilities are appropriate for combustion studies in academia. The features explained above are highly useful. Moreover, a prediction of **thermodynamic properties** of combustion products and **equilibrium composition** can be obtained.

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



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