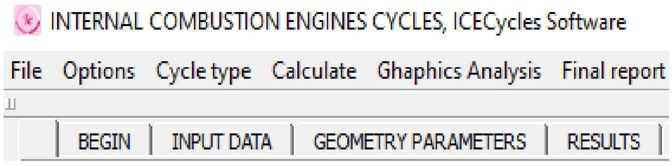
# ICECycles

## ICECycles | Technical & Educational Software




ICECycles is a software for the theoretical calculation of cycles of internal combustion engines. The fuel can be introduced as a mixture of hydrocarbons (liquid or gas) or by an "ultimate analysis". The principles of thermodynamics and the relations between properties of gases are the basic equations employed in it.

## INDEX

### 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

ICycle Otto, Diesel and Dual, together actual cycle including geometric parameters of the engine. In Otto cycle, heat addition takes place through constant volume process whereas in Diesel cycle, heat addition takes place through constant pressure process.

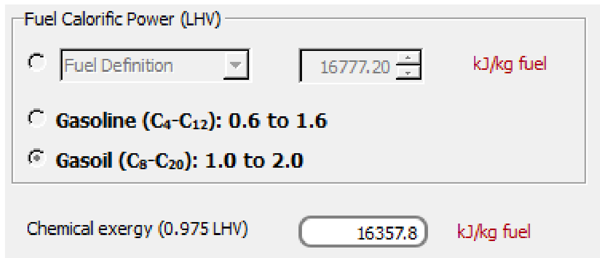
A variety of engine models are used in the software developed, with a range of complexity. This program can also be used within any class to help illustrate the first and second laws of thermodynamics applied to engines.

## Characteristics

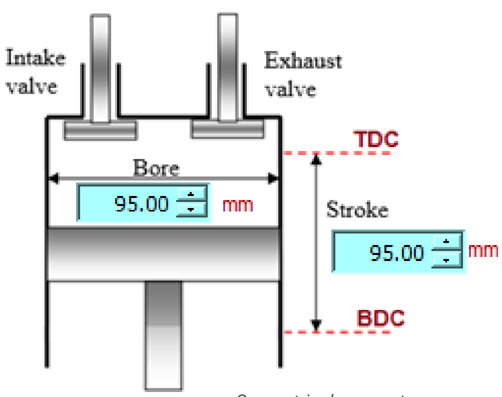
Software algorithms are based on up-to-date bibliography and the latest mathematical models, which in conjunction result in a **well-defined** and **solid technology**. The software has been set up with an **intuitive interface** that allows **easy handling**.

### Input variability (geometrical parameters)

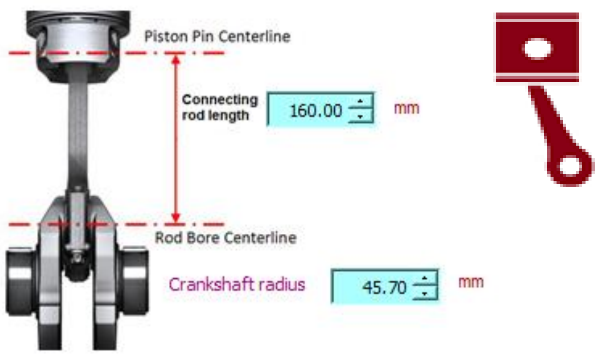
Modelling and computer simulation of an internal combustion engine's operating processes offers a valuable tool for enhancing our understanding of real physical phenomena and contributes significantly to optimizing and controlling the engine's operation to meet different objectives.



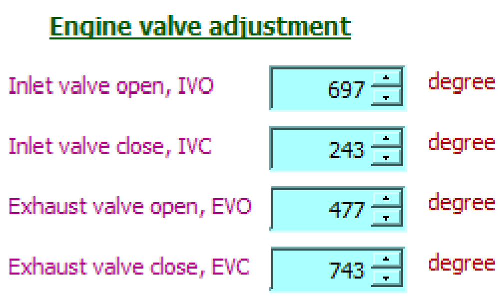

*Fuel selection features*

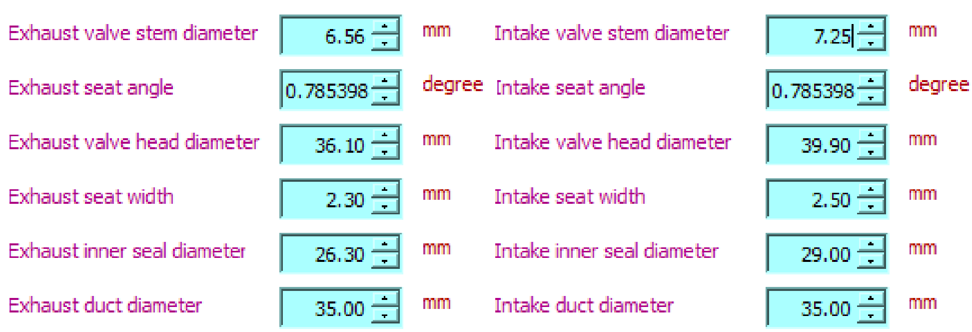



*Geometrical parameters*




*Geometrical parameters*



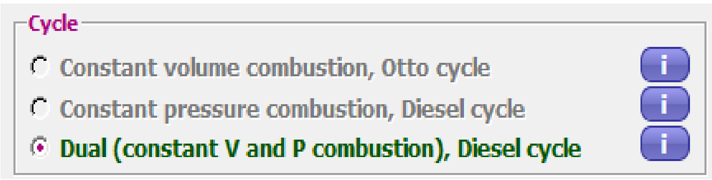



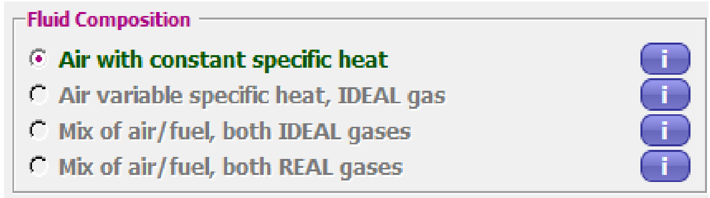

*Geometrical parameters*

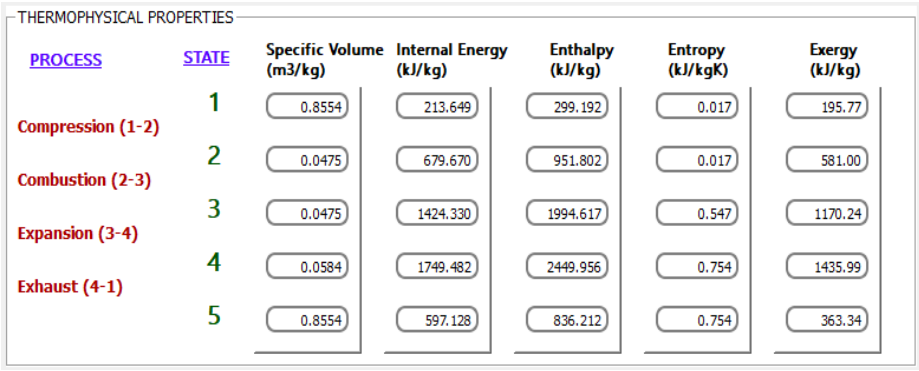
## Software capabilities

### Thermodynamic análisis (Numerical response)

ICECycles is at the forefront of thermal technology, offering innovative and efficient thermal energy solutions applied to engines. The software developed has the ability to use tables or functios to determine the properties of the fluids considered, ideal gas (specific heat temperature dependent), and fuel/air (gasoline and gasoil). These properties are the internal energy, enthalpy and entropy in function of the temperature for different values of the excess air coefficient.



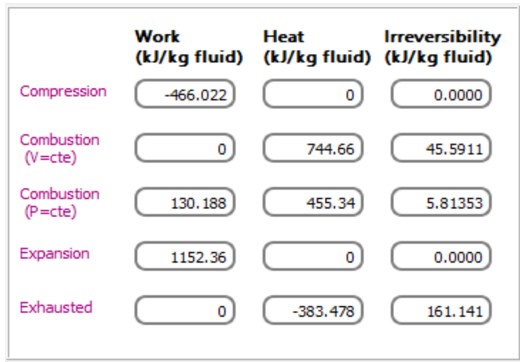



THERMOPHYSICAL PROPERTIES

| PROCESS | STATE | Specific Volume (m3/kg) | Internal Energy (kJ/kg) | Enthalpy (kJ/kg) | Entropy (kJ/kgK) | Exergy (kJ/kg) |
|---|---|---|---|---|---|---|
| | 1 | 0.8554 | 213.649 | 299.192 | 0.017 | 195.77 |
| Compression (1-2) | | | | | | |
| | 2 | 0.0475 | 679.670 | 951.802 | 0.017 | 581.00 |
| Combustion (2-3) | | | | | | |
| | 3 | 0.0475 | 1424.330 | 1994.617 | 0.547 | 1170.24 |
| Expansion (3-4) | | | | | | |
| | 4 | 0.0584 | 1749.482 | 2449.956 | 0.754 | 1435.99 |
| Exhaust (4-1) | | | | | | |
| | 5 | 0.8554 | 597.128 | 836.212 | 0.754 | 363.34 |

Results interface

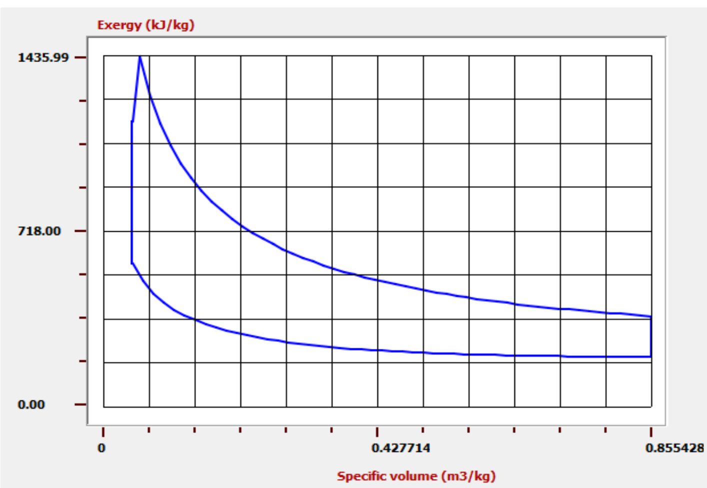


| | Work (kJ/kg fluid) | Heat (kJ/kg fluid) | Irreversibility (kJ/kg fluid) |
|---|---|---|---|
| Compression | -466.022 | 0 | 0.0000 |
| Combustion (V=cte) | 0 | 744.66 | 45.5911 |
| Combustion (P=cte) | 130.188 | 455.34 | 5.81353 |
| Expansion | 1152.36 | 0 | 0.0000 |
| Exhausted | 0 | -383.478 | 161.141 |

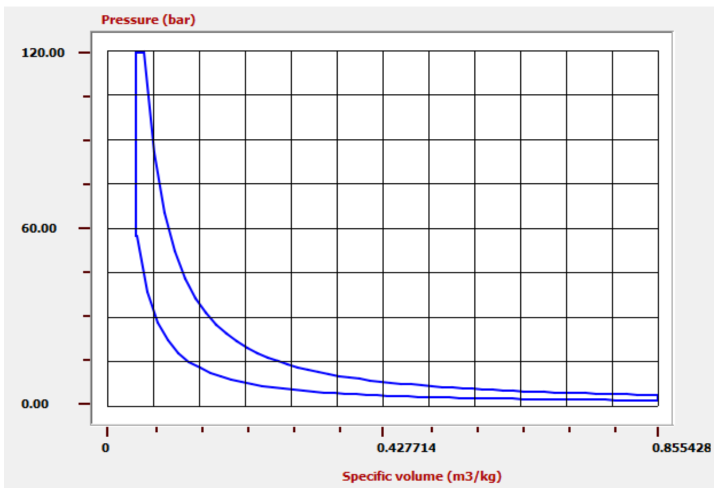
Results interface

### Thermodynamic analysis (Graphic response)

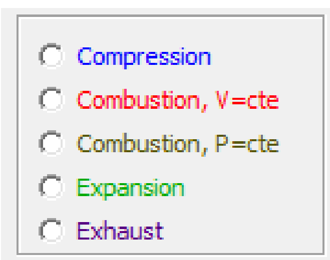
A complete sensitivity analysis of the main motor design variables. Thermodynamic analysis. Heat transfer analysis. Kinematics and load analysis.
The students vary typical engine parameters such the displacement, compression ratio, supply of fuel, type of fuel (gasoline or diesel), calorific power of the fuel, mass of fluid, excess air coefficient, alpha, beta and polytropic coefficients and some thermodynamic properties (conditions at the beginning of compression). The intent is to allow rapid determination of the effect of major variables on the engine performance and efficiency. The equations are solved by means of analytical expressions providing the complete solution of all important parameters developed by the engine cycle, efficiency, work, indicated mean pressure and heat exchanged and others.

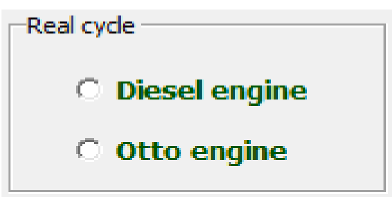


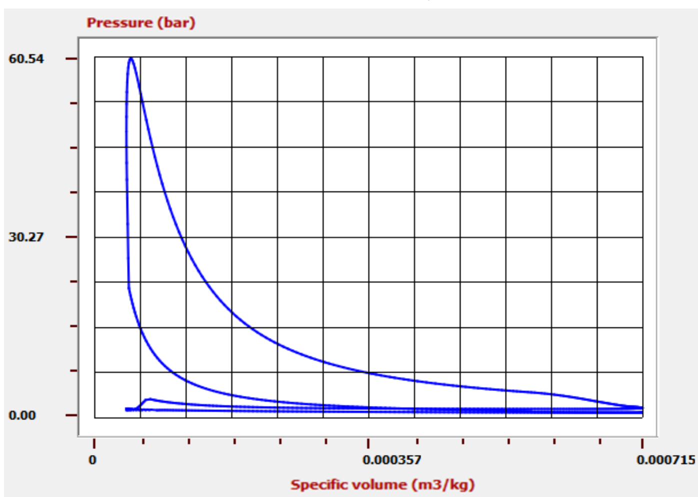

Theoretical cycle




Theoretical cycle



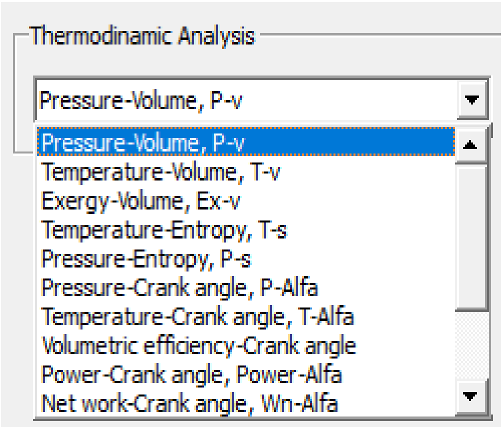



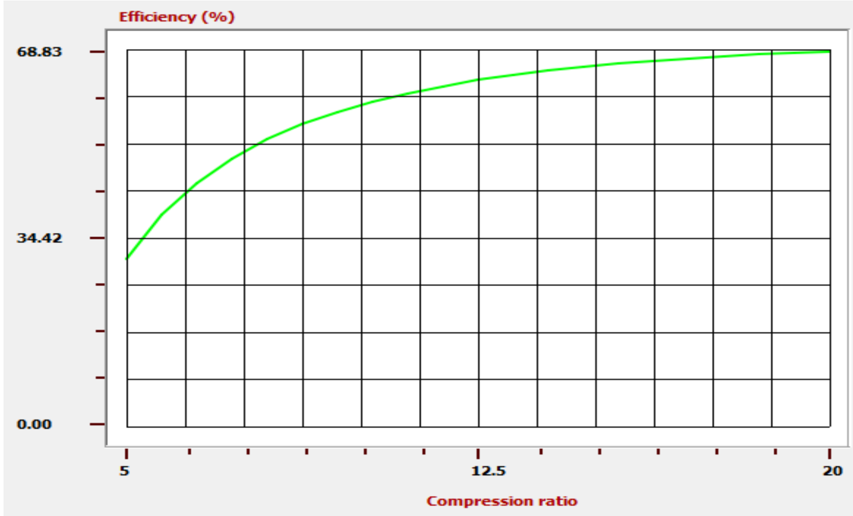



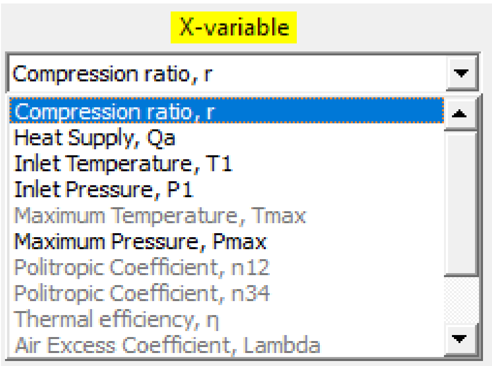

Real cycle

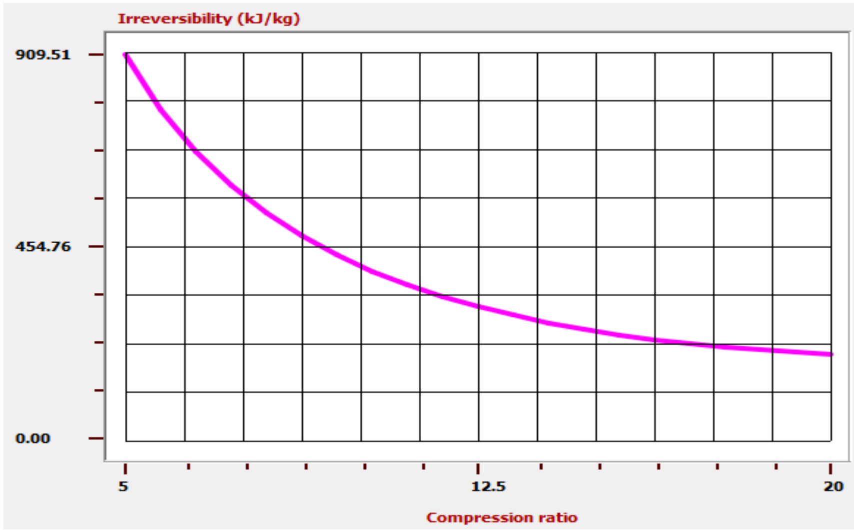
## Sensitivity analysis

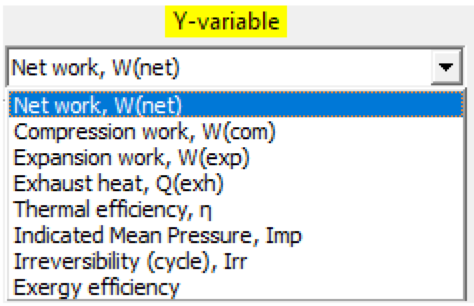
Analysis of main variables involved in the each case to solve. Graphical display of results.

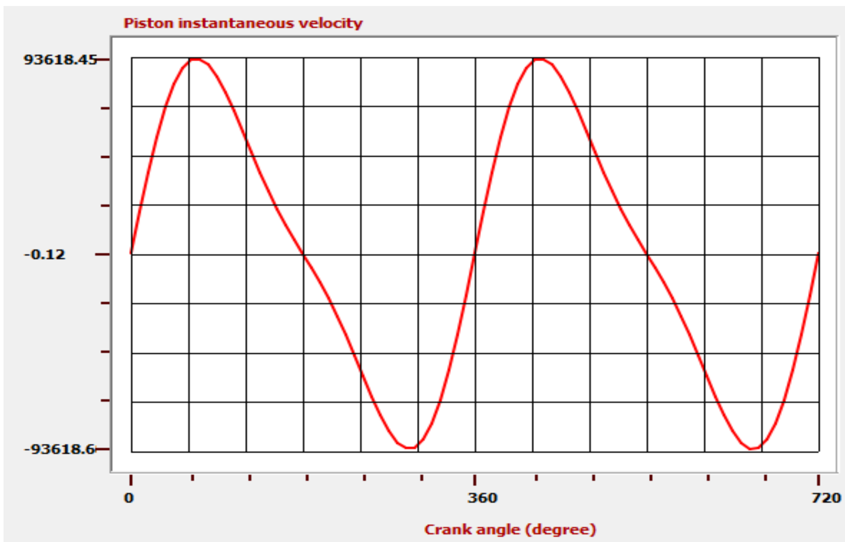


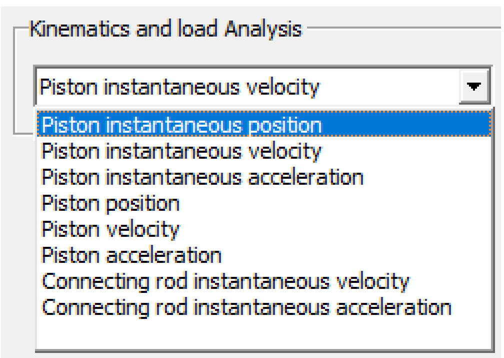



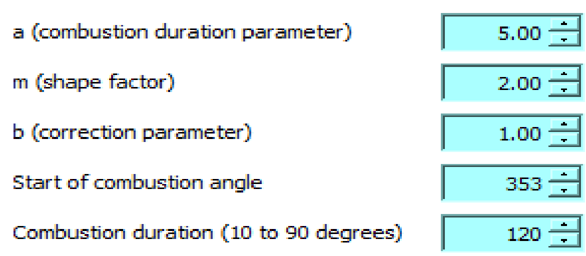




*Graphic representations of sensitivity analysis*

## Combustion modelling

Various models have been proposed to study the combustion process such as the Wiebe burning law applicable to in spark-ignition engines and the Watson law in compression-ignition engines.

$$x_b = b\left\{1 - \exp\left[-a\left(\frac{\theta - \theta_o}{\Delta\theta}\right)^{m+1}\right]\right\}$$



## Applications

In summary, ***ICECycles*** provides a complete solution of theoretical design of processes for ICE; analysing the effect of the main variables that participate in the process, through the possibility of performing a graphical sensitivity analysis.

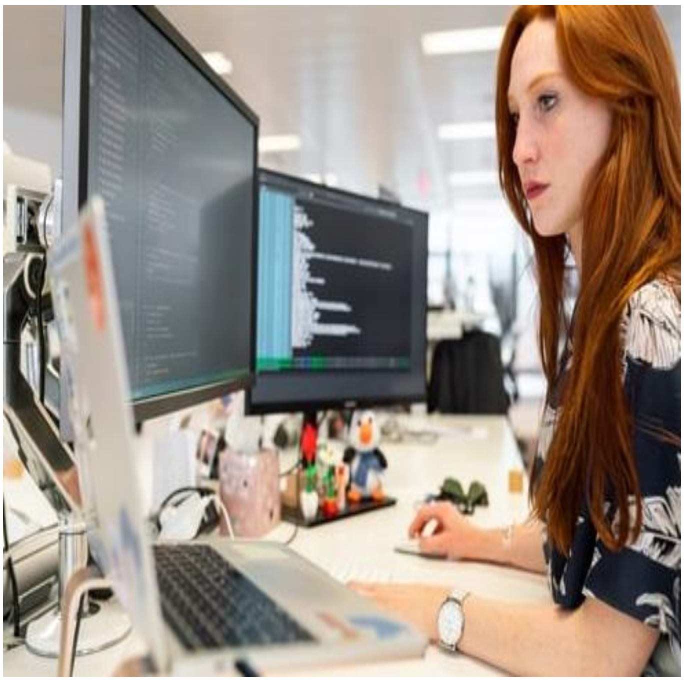
Whole range of software capabilities facilitates an improvement in these process design, an exhaustive study of main variables effects, and the possibility to reduce irreversibilities or pollutant emissions. A final report (set up by the user) can be submitted, containing graphs and predictions.

### Academia application specifications

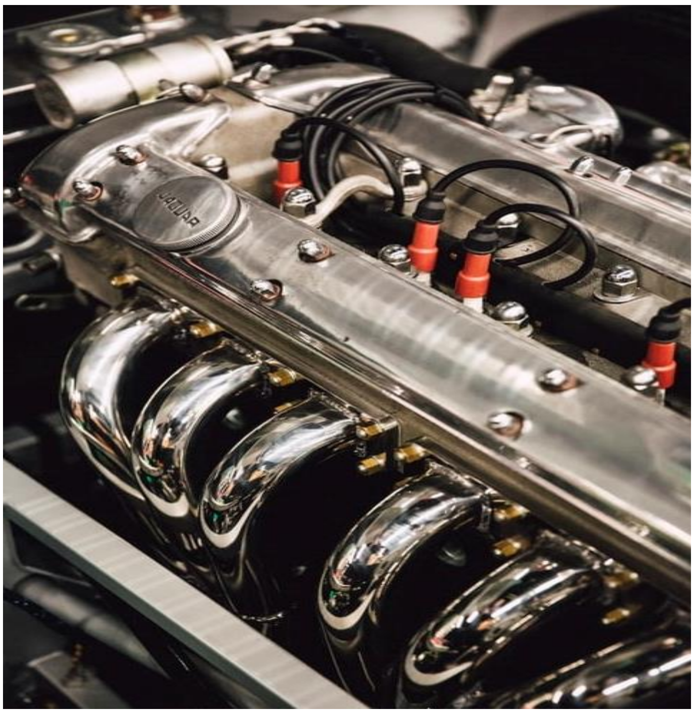
This software's capabilities are appropriate for the studio of Internal Combustion Engines in academia. The features explained above are highly useful; however, some additional ones should be taken into consideration. ICECycles software can be used as an integrating application in the thermal sciences stem of the engineering undergraduate curriculum.

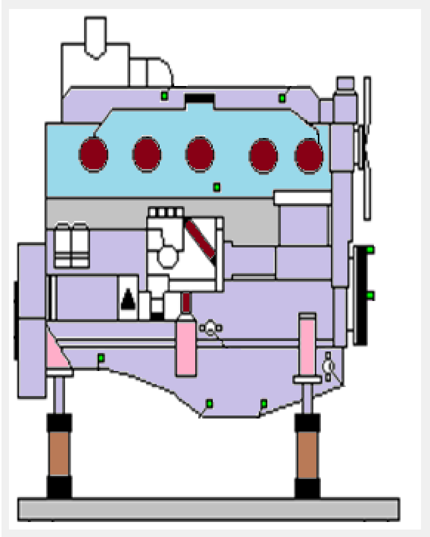
ICECycles is a software for the theoretical calculation of cycles of internal combustion engines (MCIA). It allows different models of fluids, air as perfect gas, air as ideal gas, air and fuel mixture both treated as ideal gases and mixture of air and fuel as real gases. Analyzes the three types of combustion processes for Otto and Diesel engines.

Engine valve adjustment



The software has been developed to solve many problems and it facilitates understanding of the thermodynamic fundamentals of an internal combustion engine. It demonstrates the power of such an engine simulation tool in an educational setting.
ICECycles include many academic aspects which can greatly help students to better understand the physical aspects of the internal combustion engine cycles.





Engine test bench