Property Database for Humid Combustion Gases, Humid Air, Water and Steam for Calculating Heat Cycles and Turbines

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The developed program packages for calculating thermophysical properties and plotting thermodynamic charts of humid combustion gases, humid air, water and steam are meant for the daily work of the engineer who calculates heat cycles, steam and gas turbines, or other thermal processes. Thermodynamic properties, transport properties, thermodynamic derivatives and inverse functions can be calculated.

Today, gas turbines are being developed for higher and higher temperatures and pressures. However, the calculation of the combustion gases as ideal gas mixtures will be inaccurate at high pressures. Therefore, the property library LibHuGas has been developed for humid combustion gases calculated as ideal mixtures of real fluids. For increasing accuracy, the main components - carbon dioxide, steam, nitrogen, oxygen, and argon - are calculated by accurate fundamental equations [1]...[5]. The new scientific standard [6] is used for calculating the ideal gas parts of all components. The poynting effect for the saturation pressure of water in a gas atmosphere under pressure is taken into consideration. At high temperatures, the influence of the dissociation of the components is calculated from the VDI Guideline 4670 [7].
For lower pressures, the library LibIDGas, which includes the ideal gas algorithms of the VDI Guideline 4670, has been set up.

At present, processes using humid air as a working fluid are designed for pressures up to 10 MPa and higher. For example, the advanced adiabatic compressed air energy storage technology requires very accurate algorithms for the thermodynamic and transport properties of humid air at low temperatures and high pressures. At these parameters, humid air cannot be calculated as an ideal gas mixture. Therefore, the property library LibHuAir has been developed. It contains the calculation of humid air as an ideal mixture of the real fluids - dry air and steam - plus water or ice respectively. Dry air is calculated from the accurate fundamental equation of Lemmon at al. [8], while for steam and water, the industrial standard IAPWS-IF97 [9] is used. Again, the poynting effect and the influence of dissociation is taken into consideration.
As an alternative, the library LibIDAir, which includes the ideal gas algorithms of the VDI Guideline 4670, can be used at lower pressures.

For modelling heat cycles and steam turbines the property library LibIF97 has been set up. It calculates the thermodynamic and transport properties of water and steam using the industrial formulation IAPWS-IF97 [9].

The following software solutions will be presented:

- Dynamic Link Libraries for use in Windows programs
- Add-In FluidEXL*Graphics* for Excel® including graphical representation of the calculated properties in thermodynamic charts
  (*T*,*s*- , *h*,*s*- , log*p*,*h*- , log*p*,log*v*- , log*p*,*T*- , *p*,*T*- , *T*,*h*- , *T*,log*v*- , log*p*,*s*- , *h*,log*v*- and *s*,log*v*-diagram)
- Library FluidMAT for Mathcad®
- Dialog program FluidDAT*Graphics* for use as electronic steam table in Windows including graphical representation of the calculated properties in thermodynamic charts (same diagrams as for FluidEXL*Graphics*)
- Program FluidDIA for calculating and plotting large size and camera-ready thermodynamic charts (*h*,*s*- *T*,*s*- log*p*,*h*- and *h*,*x*-diagram)
  The range of state of the diagram, isolines , scale and size can be adjusted by the user.
- Software for Pocket Computers:
  FluidTI for Texas Instruments® TI 89 and TI 92
  FluidHP for Hewlett Packard® HP 48G and HP 49
  FluidFX880 for Casio® FX 880P
  FluidCASIO for Casio® CFX-9850GB .

Student versions of all programs are available.

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