Equations $p(h,s)$ for Water and Steam

Hans-Joachim Kretzschmar, Ines Stöcker, Katja Knobloch,
Department of Technical Thermodynamics, University of Applied Sciences of Zittau and Görlitz, D-02754 Zittau, Germany

Jens Trübenbach, Thomas Willkommen, and Achim Dittmann
Department of Technical Thermodynamics, Technical University of Dresden, D-01062 Dresden, Germany

The new Industrial Formulation IAPWS-IF97 for the thermodynamic properties of water and steam has been applied since September 1997. Besides fundamental equations the IAPWS-IF97 contains equations for the most often used backward functions $T(p,h)$ and $T(p,s)$ valid in the liquid and the vapour regions.

In addition to these, equations for the backward function $p(h,s)$, which is also used in process modeling, will be presented. The range of validity of the developed equations corresponds to that of the backward equations of the IAPWS-IF97. Their numerical consistency to the basic equations $s(p,T)$ and $h(p,T)$ of the IAPWS-IF97 is sufficient for application in heat cycle and steam turbine calculations.

With pressure $p(h,s)$, the temperature can be calculated using the IAPWS-IF97 backward equation $T(p,h)$. Because the numerical consistency of the temperature obtained in this way is also sufficient for thermodynamic process modeling, the otherwise inevitable iterations of p and T from the IAPWS-IF97 equations $s(p,T)$ and $h(p,T)$ can be avoided.

The basis for developing the equations $p(h,s)$ is a special approximation algorithm of Trübenbach and Willkommen. It is based on the structure optimization method of Wagner. The modification takes into account the computing time to run the equation while it is being developed and contains optimization of the nonlinear parameters.