FAST CALCULATION OF THERMODYNAMIC PROPERTIES OF WATER AND STEAM IN PROCESS MODELLING USING SPLINE INTERPOLATION

Matthias Kunick[a], Hans-Joachim Kretzschmar[a], and Uwe Gampe[b]

[a] Department of Technical Thermodynamics, Zittau/Goerlitz University of Applied Sciences, D-02754 Zittau, Germany
[b] Institute for Power Engineering, Chair of Thermal Power Machinery and Plants, Technical University of Dresden, D-01062 Dresden, Germany

Email: MatthiasKunick@hotmail.com

Optimizing heat cycles and calculating non-stationary processes require extremely fast algorithms for thermodynamic properties. The IAPWS-IF97 contains very fast and accurate equations. For Computational Fluid Dynamics (CFD), however, even IAPWS-IF97 is too slow. Therefore in CFD, fluid properties are often calculated with simple equations, for example with the ideal gas equation. Depending on the range of state, this procedure implies inaccuracies in the process calculation. IAPWS therefore established a task group in 2007 for developing fast property algorithms for water and steam.

In the past, so-called table look-up methods have been developed to calculate fluid properties faster and with reasonable accuracy. The Tabular Taylor Series Expansion Method (TTSE) was adopted by IAPWS as a Guideline in 2003. One disadvantage of this method is that it does not represent the property surfaces in a steady form.

Two-dimensional splines are able to represent surfaces steadily and are as fast as the TTSE method. In the first step, bi-quadratic splines for the functions $T(p,h)$ and $h(p,T)$ for region 2 of IAPWS-IF97 were developed. The computational speed of both functions is considerably faster than the IAPWS-IF97 fundamental and backward equations. The data grid of the spline-polynomials was optimized for the condition that both functions represent IAPWS-IF97 with an accuracy which is sufficient for process modelling. Moreover the spline functions $T(p,h)$ and $h(p,T)$ are completely numerically consistent with each other.

The focus of this work is the development of an algorithm enabling efficient generation of spline polynomials and the respective tables for given range of state and for given accuracy.

An investigation is in progress to determine spline-interpolation algorithms for thermodynamic properties not only for water and steam but also for other pure fluids and mixtures.