Proposal for an IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using Spline Interpolation

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Computational Fluid Dynamics (CFD), non-stationary process simulations, online monitoring and optimization of power cycles all require extremely fast computation of steam and water properties. In order to develop such property algorithms, the Task Group "CFD Steam Property Formulations" was established by the IAPWS Working Group Industrial Requirements and Solutions.

This Task Group has now prepared a new "Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using Spline Interpolation," which contains spline functions for the independent variables specific internal energy and specific volume (u,v), as well as pressure and specific enthalpy (p,h). Thermodynamic and transport properties, thermodynamic derivatives, and backward functions of the variables (p,T), (p,v), (p,s), and (h,s) are calculated in the single-phase regions steam and liquid water, and in the two-phase region wet steam. These backward functions are completely numerically consistent to each other.

The entire range of validity of the spline functions corresponds to that of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam (IAPWS-IF97).

The calculated properties are equal to those in IAPWS-IF97 within a relative uncertainty of 10 to 100 ppm (depending on the property and range of state). Consequently, the differences between the results of the process modeling in comparison with the results calculated using IAPWS-IF97 are negligible.

The computations of the (u,v) spline functions are 200 times faster than the iterative calculations using IAPWS-IF97. And even the (p,h) spline functions are twice as fast as the IAPWS-IF97 backward equations.

The spline functions are available in a property library which can be used in CFD or other applications such as non-stationary process simulations, online monitoring or optimization of power cycles.