# Fast Calculation of Thermodynamic Properties of Water and Steam Using a Spline Based Table Look-up Method – STM

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For the design and optimization of advanced power cycles and their components, extensive process simulations such as Computational Fluid Dynamics (CFD) and the calculation of non-stationary processes are used. These simulations require very fast and accurate functions for the determination of fluid properties. Furthermore, to meet the demands of numerical solvers, high numerical consistency of forward and backward functions and continuity of these functions and derivatives are required.

The task group “CFD Steam Property Formulations” was established by the IAPWS working group “Industrial Requirements and Solutions” in order to develop algorithms that fulfil these requirements. Within this task group the Spline Based Table Look-up Method, or STM, has been developed. This paper describes this method in detail, both the basic principles and all steps taken during the generation of a spline based property function for a given range of validity and accuracy.

The generation of a suitable look-up table, the grid of nodes, is the first and most crucial step in setting up a spline function. The amount of data for the desired range of validity and accuracy must be minimized while the computing speed needs to be maximized. Irregularly-shaped ranges of validity must be fitted into rectangular grids with equidistant nodes, because this approach simplifies the cell search algorithm in the grid to a straightforward calculation without iterations. The proposed method combines specialized variable transformations and extrapolation techniques to achieve these optimizations. Thereby the shape of the property function is adapted to the shape of the spline-polynomial. Consequently, the number of nodes can be minimized whereas the computational speed is kept as high as possible.

STM also enables the calculation of inverse functions with complete numerical consistency. These inverse functions are the analytic solutions of the spline polynomials solved in terms of one of their independent variables.

For generating such spline functions, the software FluidSplines has been developed. It makes STM applicable to all kinds of one- or two-dimensional property functions. Fluid properties can be provided from external databases such as the property libraries of the Zittau/Goerlitz University or REFPROP from NIST. The software implements all the features of the spline-based table look-up method explained above, and assists the user in generating spline functions and inverse spline functions for a given range of validity with the required accuracy.