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CFD ANALYSIS OF STEAM TURBINES WITH THE IAPWS STANDARD ON THE SPLINE-BASED TABLE LOOK-UP METHOD (SBTL) FOR THE FAST CALCULATION OF REAL FLUID PROPERTIES

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ABSTRACT

Accurate simulations of non-stationary processes in steam turbines by means of Computational Fluid Dynamics (CFD) require precise and extremely fast algorithms for computing real fluid properties. To fulfill these requirements, the International Association for the Properties of Water and Steam (IAPWS) issues the "Guideline on the Fast Calculation of Steam and Water Properties with the Spline-Based Table Look-Up Method (SBTL)" as an international standard. Through the use of this method, spline functions for the independent variables specific volume and specific internal energy (v,u) are generated for water and steam based on the industrial formulation IAPWS-IF97. With these spline functions, thermodynamic and transport properties can be computed. The desired backward functions of the variables pressure and specific volume (p,v), and specific internal energy and specific entropy (u,s) are numerically consistent with the spline functions from (v,u). The properties calculated from these SBTL functions are in agreement with those of IAPWS- IF97 within a maximum relative deviation of 10 to 100 ppm depending on the property and the range of thermodynamic states spanned under the given conditions (range of state). Consequently, the differences between the results of process simulations using the SBTL method and those obtained through the use of IAPWS-IF97 are negligible. Moreover, the computations from the (v,u) spline functions are more than 200 times faster than the iterative calculations with IAPWS-IF97.

In order to demonstrate the efficiency and applicability of the SBTL method, the SBTL functions have been implemented into the CFD software TRACE, developed by the German Aerospace Center (DLR). As a result, the computing times required for the simulations of steam flow in a turbine cascade considering real fluid behavior are reduced by a factor of 6-10 in comparison to the calculations based on IAPWS-IF97. Furthermore, computing times are increased by a factor of 1.4 only with respect to CFD calculations where steam is considered as an ideal gas, through the use of the SBTL method.

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