



Research Activities on the Thermodynamic Properties of Water and Steam

Report "Research in Progress 2002"

1. Supplementary backward equations $T(p,h)$, $v(p,h)$, and $T(p,s)$, $v(p,s)$ for the critical and supercritical regions of water and steam
 - The backward equations $T(p,h)$, $v(p,h)$, and $T(p,s)$, $v(p,s)$ for the critical and supercritical regions were completed and successfully tested in process modelling. They can be used in combination with the Industrial Formulation IAPWS-IF97.
 - The Draft of "Supplementary Release on Backward Equations for the Functions $T(p,h)$, $v(p,h)$, and $T(p,s)$, $v(p,s)$ for the Critical and Supercritical Regions to the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam" was formulated and sent to the IAPWS Working Groups "Industrial Requirements and Solutions" and "Thermophysical Properties of Water and Steam"
2. Supplementary backward equations $p(h,s)$ for the critical and supercritical regions of water and steam
 - The division of IAPWS-IF97 region 3 into subregions was investigated.
 - First equations $p(h,s)$ for IAPWS-IF97 region 3 were developed.
3. Supplementary backward equations $v(p,T)$ for the critical and supercritical regions of water and steam
 - The division of IAPWS-IF97 region 3 into subregions was investigated.
4. Supplementary backward equations $p(h,s)$ for water and steam
 - The comprehensive publication:
Kretzschmar, H.-J., Cooper, J. R., Dittmann, A., Friend, D. G., Gallagher, J., Knobloch, K., Mareš, R., Miyagawa, K., Stöcker, I., Trübenbach, J., Wagner, W., and Willkommen, Th., "Supplementary Backward Equations for Pressure as a Function of Enthalpy and Entropy $p(h,s)$ to the Industrial Formulation IAPWS-IF97 for Water and Steam" for the Journal of Engineering for Gas Turbines and Power was completed.
5. Test of the TTSE method for calculating the thermodynamic properties of water and steam in process modelling
 - The accuracy and numerical consistency of the TTSE functions based on IAPWS-95 was investigated.
 - The computing speed of the TTSE functions was investigated and compared with that of IAPWS-95.

- The results were described in the Test Report:
Knobloch, K., Kretzschmar, H.-J., "Test Report of Documentation and Software of
TTSE Method applied to IAPWS-95 as an Example" .
6. Preparation of program packages including the Industrial Formulation IAPWS-IF97 for the power industry
 - The property library **LibHuAir** for humid air calculated as ideal mixture of the real fluids air, steam, and water was prepared. The air is calculated by the NIST standard of Lemmon at al., and water and steam are calculated by IAPWS-IF97.
 - The property library **LibHuGas** for humid combustion gas mixtures calculated as ideal mixture of real fluids was prepared. The components carbon dioxide, carbon monoxide, sulfur dioxide, nitrogen, oxygen, argon, and neon are calculated by fundamental equations and water and steam are calculated by IAPWS-95.
 7. Implementation of the Industrial Formulation IAPWS-IF97 on pocket calculators
 - The program **FluidCASIO** for the models CFX 9850G and CFX 9850GB Plus of Casio® was prepared.
 8. Property libraries for water and steam, combustion Gas mixtures, and humid air for education
 - The Versions for students of the programs
Add-In **FluidEXL** for Excel®
FluidMAT for Mathcad®
FluidTI for the pocket calculators TI 92 and TI 89
FluidHP for the pocket calculators HP 48 and HP 49G
FluidCASIO for the pocket calculator Casio FX 880P
were revised.

Zittau, July 12, 2002

H.-J. Kretzschmar