# Honorary doctorate for internationally leading RUB scientist in the thermodynamic property data of gases and liquids

On May 18, 2015, Prof. em. Dr.-Ing. habil. Wolfgang Wagner was awarded the academic degree "Doctor of Engineering Science Honorary" (Dr.-Ing. e. h.) from the Mechanical Engineering Faculty of the Dresden University of Technology due to his outstanding scientific achievements in the field of thermodynamic property data.

From 1975 onwards, Prof. Wagner represented the subject “Thermodynamics” in the Faculty of Mechanical Engineering at the Ruhr-University Bochum, initially as a C3-Professor and, after two offers of other universities, from 1984 as a C4-Professor and head of the Chair of Thermodynamics. Prof. Wagner has been retired since 2006, but continues to work scientifically with international visibility.

Prof. Wagner is one of the leading international scientists in the field of thermodynamic property data. Accurate data of thermodynamic properties of fluid substances are required, such as density, enthalpy, entropy and others for the design and operation of apparatus and systems in energy and process engineering (e.g. gas and steam turbines, entire power plants, refrigerating machines, separation devices in the chemical industry). These thermodynamic properties are calculated with equations of state, which are, over large ranges of temperature and pressure, fitted to the most accurately measured values of such thermodynamic properties, in particular the density.

**Research fields and selected results**

Against the background described, the following main research fields were worked on at the chair of Prof. Wagner:

**(1)** Development of new density measurement methods and construction of corresponding apparatus. The density measurements on 20 of the most important working substances (e.g. methane, nitrogen, ethane, ethene, carbon dioxide) in the temperature range from −210 °C to +250 °C at pressures of up to 300 bar are the world's most accurate density measurements and have reference status. Magnetic suspension balances had to be developed for the density measuring devices, which enable contactless weighing through the wall of the measuring cell (“weighing through walls”). The density measurement method developed at that time is still the most accurate method for density measurements over large ranges of temperature and pressure; it was adopted by the metrological state institutes in Great Britain, Japan, the USA and Germany (Physikalisch-Technische Bundesanstalt).

**(2)** Development of equations of state for the mentioned working substances and additionally for the working substance water, which is very important in energy technology, and the industrially also very important multi-component mixture "natural gas". These equations of state were determined with a specially developed structure optimization method and are the world's most precise equations for these substances. They are recognized as international reference equations of state and in some cases have been raised to international standards by the relevant organizations. Examples are the standards of the International Association for the Properties of Water and Steam (IAPWS), namely the scientific standard equation of state

IAPWS-95 and the industrial formulation IAPWS-IF97 for water and steam (see also the last section of this description) as well as the ISO standard of the International Organization for Standardization for the natural-gas equation of state GERG-2008. All these equations of state cover the entire fluid state (gas region, liquid region, supercritical region and the gas-liquid phase boundary).

**(3)** Further development of the magnetic suspension balances. This work led in 1990 to the establishment of the company "Rubotherm" as a start-up of the Chair of Thermodynamics. The company manufactures and sells magnetic suspension balances worldwide for investigations in the fields of sorption (adsorption, absorption, diffusion), thermogravimetry (chemical reactions, pyrolysis) and thermophysical properties (density, viscosity). Rubotherm magnetic suspension balances are on every continent.

**(4)** Highly accurate measurements extremely close to the critical point of carbon dioxide and sulfur hexafluoride. According to the current state of research, the current teaching opinion on the so-called critical exponents is not tenable.

**Further awards**

In recognition of his outstanding theoretical and experimental contributions in the field of thermodynamic properties of gases and liquids, Prof. Wagner received important international prizes: In 2008 the Gibbs Award of the International Association for the Properties of Water and Steam, which is only given every four to five years. In 2003 the Touloukian Award from the American Society of Mechanical Engineers. According to general opinion, it is the highest international prize in the field of thermophysical property data, which is only awarded every three years. In 1998 the IAPWS Honorary Fellow Award.

There are only two scientists in the world who have received these two international awards.

**Connection to the Dresden University of Technology**

Prof. Wagner has been in close contact with the Mechanical Engineering Faculty at the Dresden University of Technology since 1988. With his support and the joint research results, the Dresden University was able to develop an internationally recognized position in the field of thermodynamic properties of gases and liquids. For example, the industrial formulation IAPWS-IF97 for water and steam as well as five additional IAPWS standards were developed in cooperation with the Dresden University of Technology, Prof. Achim Dittmann, and the University of Applied Sciences Zittau / Görlitz, Prof. Hans-Joachim Kretzschmar.