40 years of dynamic pulse-calorimetry at TU Graz – From room temperature up to the critical point

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During the last 40 years an increasing demand for thermophysical data of liquid metals and alloys has been noticed. Properties of matter at very high temperatures are useful for high-temperature technologies such as used in aerospace (e. g. simulation of the melting of re-entering space debris), for nuclear energy, for the establishment of temperature reference points above the freezing point of gold, for modelling of various casting processes, electro arc refinemet processes and metal powder production in steel industry, as well as for laser powder 3d printing and finally to obtain phase diagrams up to the critical point.

Starting 40 years ago with a very fast ohmic pulse heating system the Thermophysics and Metalphysics Group at TU-Graz continuously improved their experimental equipment to extend the number of thermophysical properties to study and to improve the accuracy of the data to be measured .

The next step was therefore to set up a slower pulse heating system, which was then improved by several different pyrometers, a high pressure sample chamber capable of pressures up to 5000 bar, a fast CCD camera and a microsecond Division of Amplitude Polarimeter (DOAP) to measure normal spectral emissivity at 684,5 nm.

Further a differential scanning calorimeter (DSC) Netzsch DSC 404 was added to our experimental equipment and incorporated into the basic measurement routines for data in the temperature range of about 500 K to 1500 K, as well as a differential thermal analysis (DTA) in the temperature range from 400 K to 1700 K. To improve resistivity measurements from room temperature up to 1300 K a 4 point apparatus was constructed.

To measure surface tension of liquid metals and alloys, electromagnetic levitation (EML) provides an elegant method of noncontact containerless measurement, eliminating most interactions between the sample and its environment. This technique has also been successful added to our experimental equipment.

In the last year my coworkers could also evaluate data measured in microgravity during a parabolic flight and from measurements at ELF, the Japanese electrostatic levitation furnace on board the International Space Station.

The following thermopysical properties as function of temperature for solid and liquid metals and alloys have been measured at TU Graz: Specific enthalpy, H, heat of fusion, ΔH, isobaric/isochoric heat capacity, c_p/c_v, density, d, electrical resistivity, ρ, thermal conductivity, λ_E, thermal diffusivity, a, phase transition temperatures, melting temperature (for pure metals), Tm, solidus/liquidus temperature (alloys), T_S/T_L, normal spectral emissivity, ε_λ, critical pressure, p_c, critical volume, V_c, critical temperature, T_c, equation-of-state (EOS) parameters, viscosity, η, surface tension, γ. The data obtained have been reported in about 150 scientific papers.