APPLICATION**NOTE**

Metals – Differential Scanning Calorimetry

Thermal Characterization of 1.4301 Stainless Steel: Determination of the Specific Heat Capacity

Dorothea Stobitzer, Applications Laboratory Selb

Introduction

Determining the specific heat capacity (c_p) of 1.4301 stainless steel is crucial for understanding its thermal behavior in real-world operating conditions. This fundamental material data is essential for designing and optimizing thermal processes in industry. Typical areas of application include plant and process engineering, as well as the food and chemical industries, where stainless steel is often used as a structural material. Knowledge of precise heat storage capacity is particularly important in applications involving cyclic or transient temperature loads. This enables more realistic thermal simulations to be performed and improves the operational safety and efficiency of components.

DSC-c_p, Determination

The specific heat capacity (c_p) is typically determined using DSC via a comparative measurement method with a reference material (e.g., in accordance with DIN EN ISO 11357).

First, a suitable calibration is performed on the DSC (usually temperature calibration). Each specific heat capacity determination of a material includes three measurements; the baseline, a sapphire reference sample and the sample itself and can then be calculated according to the following equation:

$$c_P = \frac{Signal\ difference\ (sample - baseline)}{sample\ mass\ *\ heating\ rate\ *\ sensitivity}$$

All measurements are performed at a defined heating rate in an inert gas atmosphere to ensure consistent conditions. The specific heat capacity (c_p) is determined within a defined temperature range. Stable baselines and high reproducibility of the measurement conditions are essential.

During the measurement, the DSC records the heat flow as a function of temperature. When calculating the specific heat capacity, the amount of heat energy absorbed by the sample compared to the standard material is taken into account. Phase transitions or reactions within the sample may affect the evaluation. Second-order phase transitions, such as glass transitions, must therefore be taken into account, whereas first-order phase transitions, such as melting processes, must be excluded.

The result provides the temperature-dependent apparent* specific heat capacity of the sample, which can be used for material characterization or further thermophysical calculations. The exact measurement conditions are shown in table 1.

Table 1 DSC measurement parameters

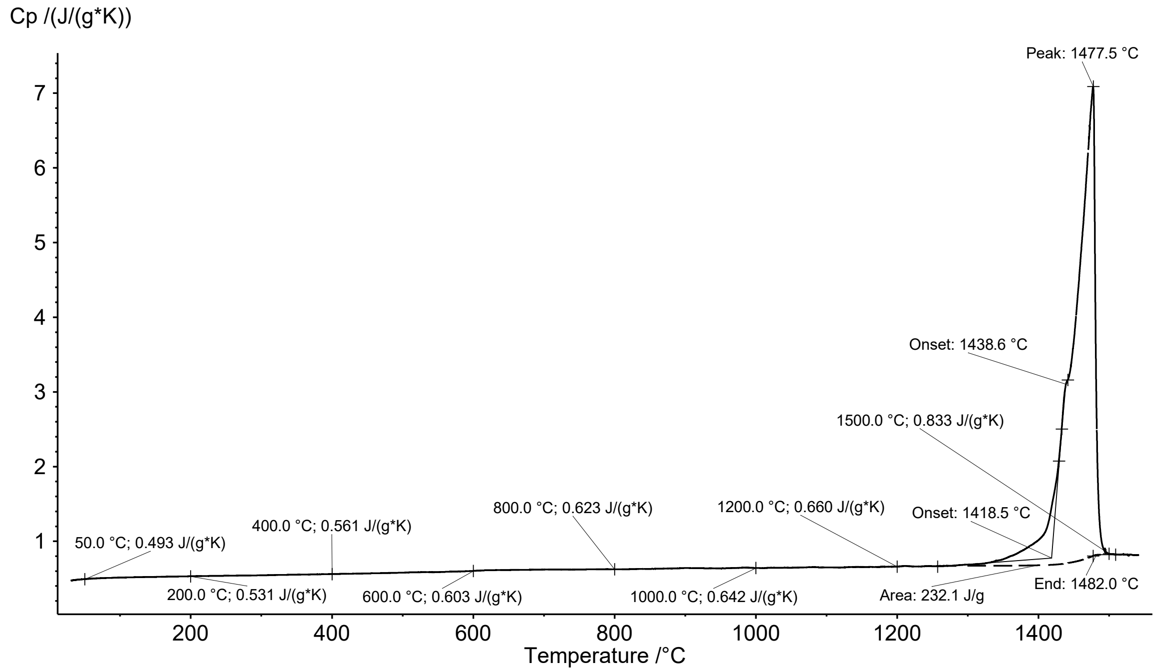
Measuring head	DSC-c_p of the DSC 500 *Pegasus*®
Furnace	Rhodium
Crucible	Pt/Rh crucible with lid (with Al_2O_3-Liner)
Sample thermocouple	Type S
Purge gas	Ar (70 ml/min)
Temperature program	• Isothermal segment at 25°C for 15 min • dynamic segment: 25°C to ~ 1550°C at 20 K/min heating rate • isothermal segment at 1550°C for 10 min
Sample mass	140.952 mg
Calibration standard	Sapphire (83.265 mg)

*The apparent specific heat capacity is a term in thermodynamics, used to describe the thermal behavior of materials which undergo phase transitions (e.g., melting, evaporation) during heating or cooling.

NGB · Application Note 444 · EN · 0526 · Technical specifications are subject to change.

NETZSCH-Gerätebau GmbH
Wittelsbacherstraße 42 · 95100 Selb · Germany
Phone: +49 9287/881-0 · Fax: +49 9287/881505
at@netzsch.com · www.netzsch.com

NETZSCH



1 Apparent specific heat capacity of 1.4301 stainless steel.

Results and Discussion

Figure 1 shows the measurement curve, illustrating the temperature-dependent apparent specific heat capacity (c_p) of 1.4301 stainless steel in the range from room temperature to approximately 1550°C. At the beginning and during heating (up to approximately 1200°C), the material shows, as expected, largely stable behavior with a slight increase in c_p values. The measured values here range from approximately 0.49 to 0.66 J/(g·K). A distinct rise in the c_p curve can be observed starting at approximately 1400°C. The transformation starts at approximately 1418°C, while a pronounced endothermic effect is observed at 1477.5°C. This sharp peak is typical of a first-order phase transition and indicates the melting process of the material. In the region of the melting reaction, additional energy is required for the transformation from the solid to the liquid state (latent heat), which is reflected in the sharply increased apparent c_p value and the broad peak structure. In the range of a melting transition, c_p is not uniquely defined due to the latent heat associated with the phase transition.

Integration of the peak yields a transformation enthalpy of approximately 232 J/g, representing the energetic signature of the melting process. The transformation endpoint is at around 1482°C, by which point the material is fully in the liquid state.

Summary

Determination of the specific heat capacity provides comprehensive thermophysical information that is crucial for characterizing materials and developing processes. A key advantage is that it captures the full thermal behavior across an extremely wide temperature range, including the solid state, phase transitions and melting. This enables consistent datasets to be created for parameters such as c_p, enthalpy and melting enthalpy, without any data gaps. Furthermore, measuring down to the melting point enables the unambiguous identification and quantification of phase transitions, particularly the melting temperature and the associated latent heat. This is especially relevant for alloys such as 1.4301 stainless steel. This data can be incorporated directly into thermal simulations (e.g., casting or high-temperature processes), enabling the realistic modelling of heating, melting and solidification processes.

The DSC 500 *Pegasus*® allows for precise c_p measurements across a wide temperature range. Due to the system's high sensitivity and stable measurement conditions, thermophysical material properties can reliable be determined, even in demanding high-temperature applications.

NGB · Application Note 444 · EN · 0526 · Technical specifications are subject to change.

NETZSCH-Gerätebau GmbH
Wittelsbacherstraße 42 · 95100 Selb · Germany
Phone: +49 9287/881-0 · Fax: +49 9287/881505
at@netzsch.com · www.netzsch.com

NETZSCH