MSE 310 Lecture 8
Principle of Calorimetry and Dilatometry

Calorimetry Physics Meaning

This is the branch of heat transfer that deals with the measurement of heat. The heat is usually measured in calories or kilo calories.

Principle of Calorimetry

The **principle of calorimetry** indicates the law of conservation energy, i.e. the total heat lost by the hot body is equal to the total heat gained by the cold body.

Heat lost = Heat gain

If two substances having masses m_1 and m_2, specific heats c_1, and c_2 kept at temperatures T_1 and T_2 ($T_1 > T_2$) are mixed, such that temperature of mixture at equilibrium is T_{mix}.

Then,

$m_1.c_1(T_1 – T_{mix}) = m_2c_2(T_{mix} – T_2)$

Calorimetry is the process of measuring the amount of heat released or absorbed during a chemical reaction. By knowing the change in heat, it can be determined whether or not a reaction is exothermic (releases heat) or endothermic (absorbs heat). Calorimetry also plays a large part of everyday life, controlling the metabolic rates in humans and consequently maintaining such functions like body temperature.

- **Constant Pressure Calorimetry**

  Because calorimetry is used to measure the heat of a reaction, it is a crucial part of thermodynamics. In order to measure the heat of a reaction, the reaction must be isolated so that no heat is lost to the environment. This is achieved by use of a calorimeter, which insulates the reaction to better contain heat. Coffee cups are often used as a quick and easy to make calorimeter for constant pressure. More sophisticated bomb calorimeters are built for use at constant volumes.

- **Constant Volume Calorimetry**

  Constant Volume calorimetry, is used to measure the heat of a reaction while holding volume constant and resisting large amounts of pressure. Although these two aspects of bomb calorimetry make for accurate results, they also contribute to the difficulty of calorimetry. Here, the basic assembly of a bomb calorimeter will be addressed, as well as how calorimetry relates to the heat of reaction and heat capacity and the calculations involved in regards to these two topics.

- **Differential Scanning Calorimetry**

  Differential scanning calorimetry is a specific type of calorimetry including both a sample substance and a reference substance, residing in separate chambers. While the reference chamber contains only a solvent, the sample chamber contains an equal amount of the same solvent in addition to the substance of interest, of which the ΔH is being determined. The ΔH due to the solvent is constant in both chambers, so any difference can be attributed to the presence of the substance of interest.

Dilatometry

Dilatometry is another technique used to study phase transitions in alloys. This technique utilizes the change in volume associated with nearly all transitions and measures the change of length of a specimen as it is heated and cooled at a fixed rate.Or Dilatometry is a thermo-analytical method for measuring the shrinkage or expansion of materials over a controlled temperature regime.

The amount of expansion or shrinkage is dependent on the characteristics of the material itself. It is often very important to match the thermal expansion behaviour of different materials that are in contact with one another in order to avoid unwanted stresses and possible cracking.

Most materials can be measured by dilatometry including glasses, ceramics, resins, polymers and metals.Dilatometry (DIL) is a technique in which a dimensional change of a substance under negligible load is measured (e.g. expansion measurement or shrinkage measurement) as a function of temperature while the substance is subjected to a controlled temperature program in a specified atmosphere.

The following measurement results can be obtained by Dilatometry:

- determination of thermal expansion coefficient (CTE)
- linear thermal expansion (ΔL)
- sinter-temperatures and sinter steps
- determination of glass transition (Tg)
- phase changes

- optimization of burning processes
- volume changes
- Rate Controlled Sintering (RCS)
- decomposition
- density change

The coefficient of linear expansion – CTE

The coefficient of linear expansion is taken as the property for the change in length. The sample is placed on a sample holder in the furnace. A push rod made of the same material as the sample holder (quartz glass, aluminium oxide) transfers the thermal expansion of the sample to a displacement transducer which measures the displacement. The displacement is measured analog or digital.

The geometric dimensions of materials vary with changes in temperature. This can be described with the following linear coefficient of thermal expansion (CTE):

$CTE\_linear = \Delta L \cdot 1/\Delta T \cdot 1/L$

ΔL represents the change in length, which is caused by a change in the temperature (ΔT) in the length (L) of the sample

The displacement transducer is firmly attached to the reference. Since the reference and the push rod are also extended in the same way during heating, the sample expansion is measured relative to the material of the reference. The actual thermal extension of the sample is then equal to the value measured by the displacement transducer plus the expansion of a piece of reference material of the same length as the sample.