Measurement and Industrial Instrumentation

ME 3225

Credit: 3.00

Measurement of pH & Thermal Conductivity

Presented By

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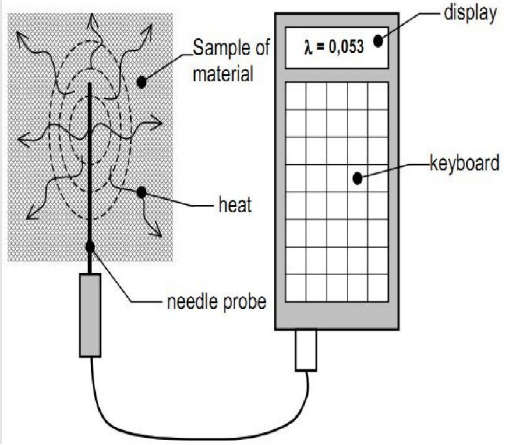
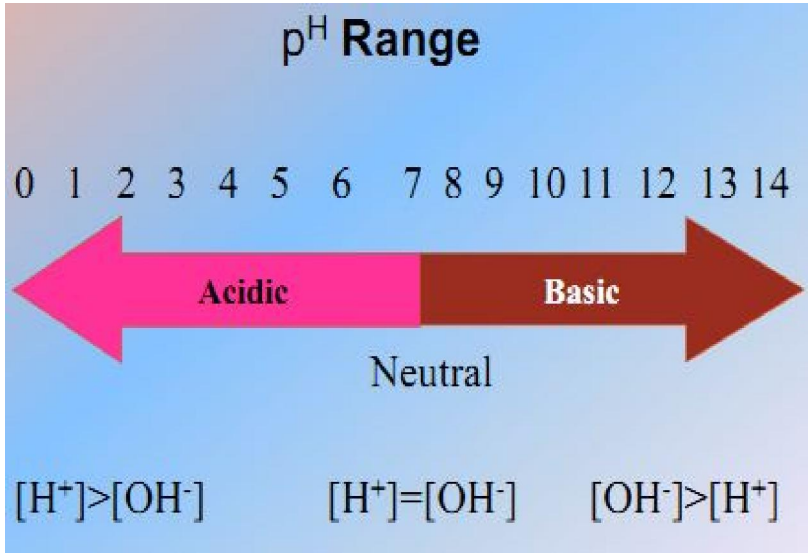


pH

- pH is a measure of hydrogen ion concentration in aqueous solution.
- It is an important parameter to determine the quality of water. The pH value is expressed as:

$$p^H = -\log[H^+]$$

- pH is a unit of measure which describes the degree of acidity or alkalinity (basic) of a solution.
- It is measured on a scale of 0 to 14.



pH Measurement
(Basic Equation)

- The pH meter detects the change in potential and determines $[H^+]$ of the unknown by the Nernst equation:

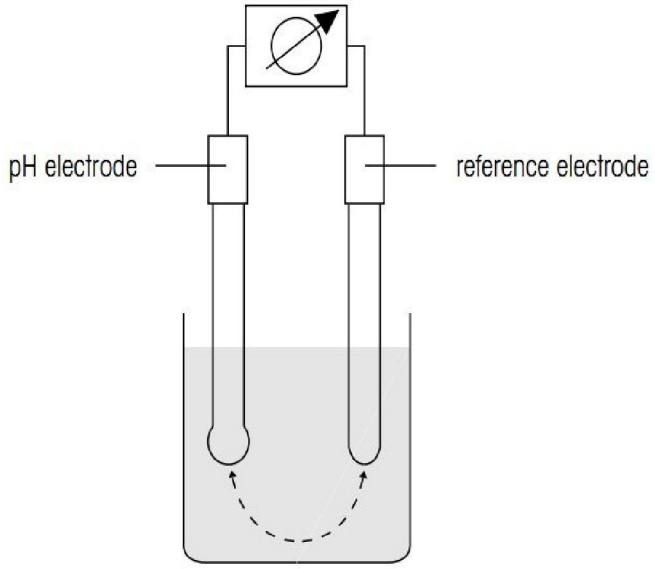
$$E = E° + \frac{2.3RT}{nF} \log \frac{unknown\ [H^+]}{internal\ [H^+]}$$

where:

E	is the total potential (measured in mV)
E°	is the reference potential
R	is the gas constant
T	is the temperature in Kelvin
n	is the number of electrons/Valence of ion
F	is Faraday's constant
$[H^+]$	is hydrogen ion concentration

P^H Measurement (P^H Meter)

- The pH value of a solution is measured by using pH electrode/meter.
- It essentially consists of a pair of electrodes: *measuring and reference electrode*, both dipped in the solution of unknown p^H.
- These two electrodes essentially form two half-cells; the total potential developed is the difference between the individual electric potential developed in each half cell.



P^H Meter

- The pH measuring electrode is a hydrogen ion sensitive glass bulb.
- The reference electrode output does not vary with the activity of the hydrogen ion.
- A sample is placed in a cup and the glass probe at the end of the retractable arm is placed in it.
- The probe is connected to the main box. There are two electrodes inside the probe that measure voltage.
- One is contained in liquid with fixed p^H . The other measures the acidity of the sample through the amount of H^+ ions.
- A voltmeter in the probe measures the difference between the voltages of the two electrodes. The meter then translates the voltage difference into pH and displays it on the screen.
- Before taking a pH measurement the meter must be calibrated using a solution of known p^H

P^H Meter

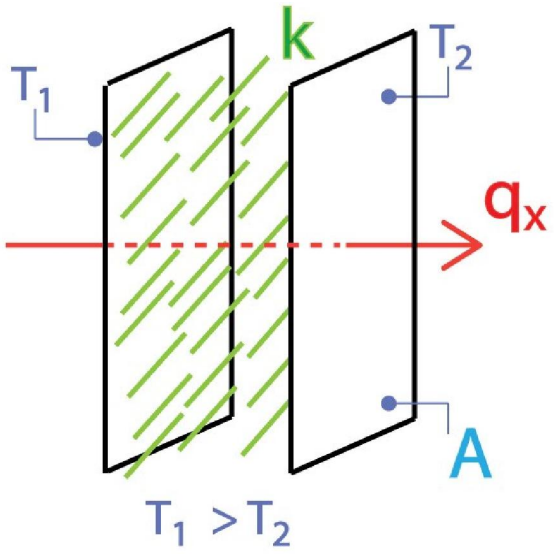

JENWAY
4.16
20.2
3510 pH Meter


9.39
23.1


PH
5.00
POWER
PeakTech
5310
PH-METER
250 ml
250
200
150
100
Made in Germany

Thermal Conductivity

- Thermal conductivity (often denoted k, λ, or κ) refers to the intrinsic ability of a material to transfer heat.
- It is evaluated primarily in terms of Fourier's Law for heat conduction. It is one of the three methods of heat transfer, the other two being convection and radiation.
- Thermal conductivity is quantified using the units of W/mK. Thermal conductivity can be calculated using the following equation:



FOURIER'S LAW

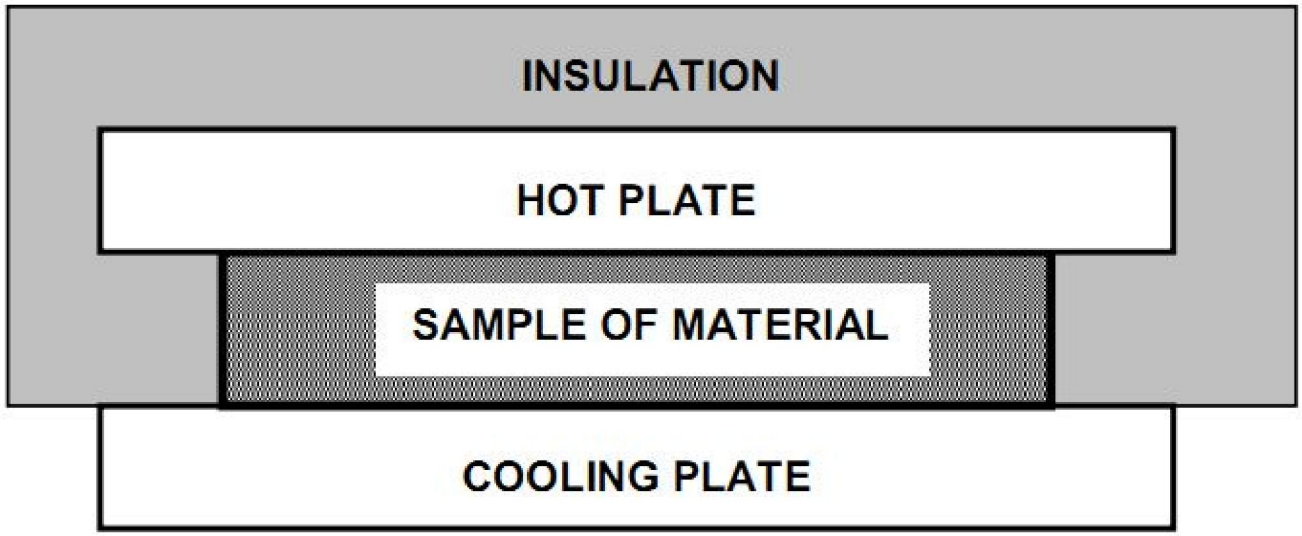
$$q_x = -k A \frac{dT}{dx}$$

Measurement of Thermal Conductivity

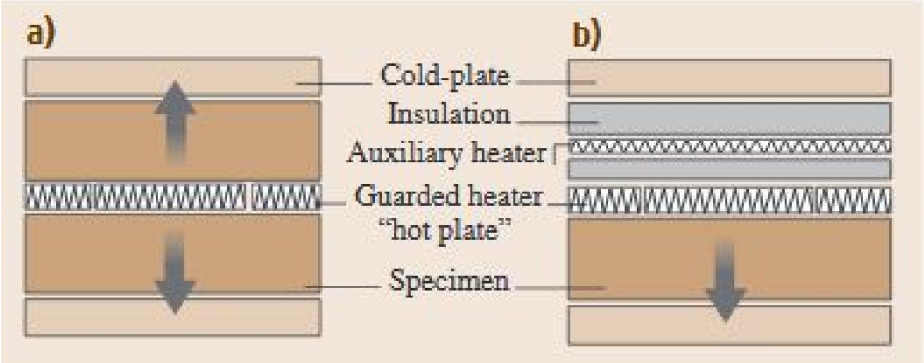
- There are four main types of instruments available to measure thermal conductivity:
  - ✓Guarded hot plate
  - ✓Hot wire
  - ✓Modified hot wire
  - ✓Laser flash diffusivity
- They differ in technique, sample size, testing time, capability and methodologies of measurement.

Guarded Hot Plate

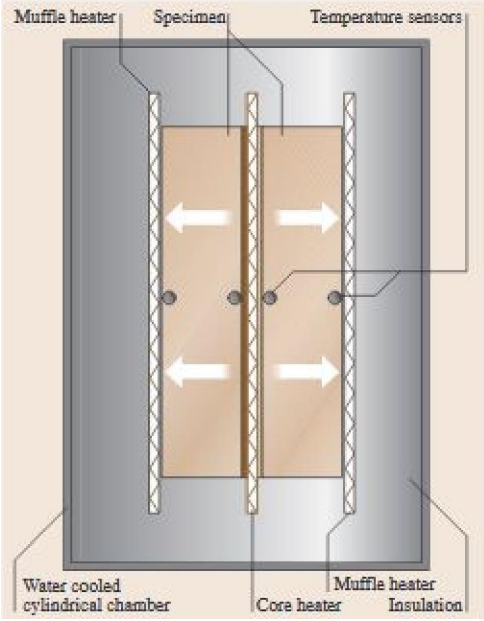
- A solid sample of material is placed between two plates.
- One plate is heated and the other is cooled or heated to lesser extent.
- Temperature of the plates is monitored until they are constant.
- The steady state temperatures, the thickness of the sample and the heat input to the hot plate are used to calculate thermal conductivity. The scheme of guarded hot place is at Figure.



Guarded Hot Plate
(steady state)

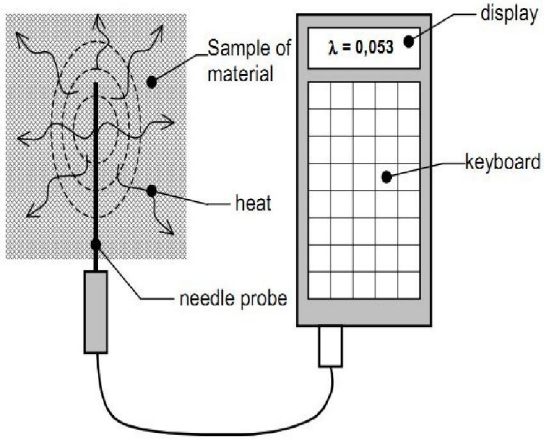


Pipe Method
(steady state)



Hot Wire

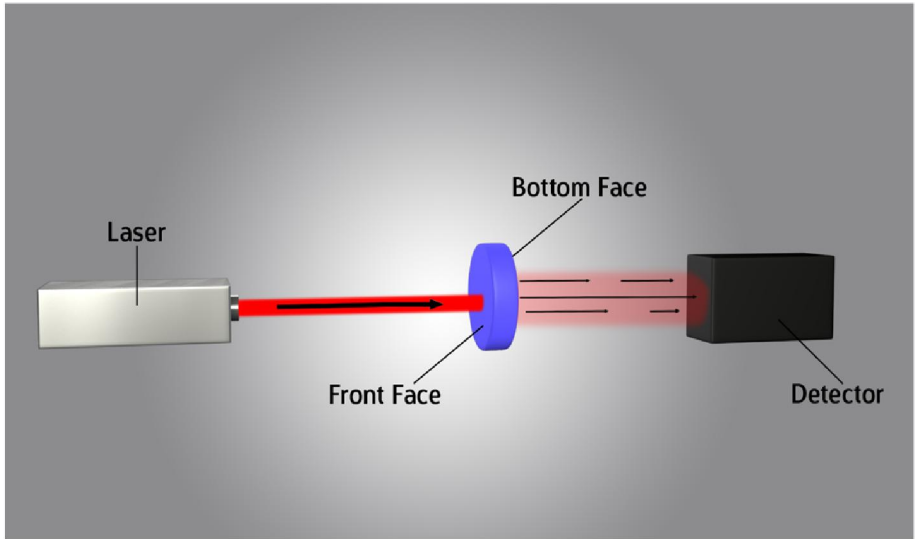
- A heated wire is inserted into the material. The heat flows out radially from the wire into the sample and the temperature change in the wire is recorded.
- The plot of the wire temperature versus the logarithm of time is used to calculate thermal conductivity, provided that density and capacity are known.
- Since this is an intrusive measure, it cannot be used for solids; it works well for foams, fluids and melted plastics. The example of hot wire apparatus is at the Figure.



Modified Hot Wire & Laser Flash Diffusivity

Modified hot wire: In this case, the hot wire is supported on backing, so the wire does not have to actually penetrate the sample. This modification allows for the testing of solid samples.

Laser flash diffusivity: A laser flash delivers short pulse of heat to the front of the sample and an infrared scanner observes the temperature change at the rare face as a function of the time.



Thank You