Thermal detectors

Detectors used to convert radiation energy into heat. They consist of an absorbing surface and a means of measuring the amount of heat absorbed. They could be sensitive to the temperature change **(thermocouple).**

Radiation may heat agas in cell and then pressure change due to heating can be measured **(Golay cell).**

Heat will change the resistance of a metal wire or semiconductor **(thermistor),** and the presence and amount of radiation can be detected when the detector sensitive element is part of an electric circuit **(bolometer).**

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All thermal detectors depend on the surface that absorb radiation. If this surface does not reflect or scatter way of the incident radiation, the device will be a good detector the usefulness of the detector depends on its ability to measure with increase in the absorbing surface .

The output of thermal detectors is proportional to the absorbed energy per unit time. This output is independent of radiation wavelength.

The response time τ of thermal detectors is generally slower than 1 ms (τ>1ms) depending on the thermal capacity (H) and heat loss per sec. per degree (G) (i.e. thermal conductivity) through the relation:

$$\tau = \frac{H}{G}$$

Short time constant therefore, requires a small H value of the detector sensitive element.

The sensitivity of thermal detectors is of order of 10^{-12} W Maximum.

Calorimetric methods of measuring energy and power thes methods are defined as those in which radiant energy i absorbed, converted to heat , that create either a temp. rise in th absorber or change in phase.

Temperature rise will result in a change in some measure, whic can be sensed directly as temp change or ascertained indirectl by monitoring changes in the volume, or pressure , or othe characteristic , such as the electrical resistance of the absorber.

In all calorimetric, heat losses (by conduction, reflection radiation, and convection) must be minimized, or controlle calibrated, and the time constant involved for therma equilibrium must be known.

1- Temperture sensing:

The amount of heat (ΔQ) required to raise the temp. of an absorber (liquid or solid) of mass (m) by an amount (ΔT) is given by;

$$\Delta Q = C_p\, m\, \Delta T \qquad \ldots\ldots \qquad (1)$$

Where C_p: is the specific heat of the absorber material at constant pressure. Small C_p values and small masses (m) are required to maximize the sensitivity of detector.

The temperature rise can be measured using thermocouples, thermopiles, bolometers, or resistance thermometers.

2- Volume sensing:

The change in a volume (ΔV) of the absorber can be used to measure the absorbed energy because:

$$\Delta V = V\beta\Delta T \quad \text{.....(2)}$$

Where V is the absorber volume, is the cubical thermal – expansion coefficient. Therefore eq.(1) becomes:

$$\Delta Q = \frac{m}{V}.\frac{C_p}{\beta}.\Delta V = \rho.\frac{C_p}{\beta}.\Delta V \quad \text{.....(3}$$ (ρ: absorber density)

A figure of merit to evaluate the volume – sensed calorimeter in liquids in the ratio $\frac{\beta}{\rho c_p}$. Thus, low densities (ρ), small C_p, and large thermal expansion coeffs (β) are required to maximize the sensitivity.

3- Pressure sensing:

In contrast to solids and liquids, gases do large amounts of work when heated at constant pressure. That is C_p of gas when heated at constant pressure is greater than that of gas at constant volume C_v.

In general $\mathbf{C_p - C_v = T \left(\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_p\right)}$

The pressure sensing can be performed using the Golay cell.

Detection of IR radiation: types of thermal detectors:

The usual means of detection of IR and far IR photons is through their heating effect. The radiant power can be measured by means of temp. or associated physical and electrical properties.

Different types of thermal detectors are available: namely

Thermoeletric detectors	Change of electric potential. (thermocouple,thermopile) Change of resistance. (bolometer,thermistor)
Pneumatic detectors	change of gas pressure. (golay cell)
Pyroelectric detectors	change of polarization of ferromagnetic materials.

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