Ministry of Higher Education and Scientific Research
Al-Mustansiriayah University
College of Engineering
Material Engineering Department

وزارةالتعليم العالي والبحث العلمي
الجامعة المستنصرية
كلية الهندسة
قسم الهندسة المواد.

مختبر

انتقال الحرارة

إعداد

مهندس: دلمن ياسين طه

إشراف

أ.م.د. عامر حميد مجيد

م.م. أسماعيل ابراهيم مرهون

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Experiment No. (5)

a. Name of Experiment:

Thermal Radiation

b. Purposes of Experiment:

1. To clarify the basic of thermal radiation.
2. Study the heat exchange between two black bodies.
3. Study the effect of distance on the intensity of radiation.
4. Study the intensity of radiation.

Introduction:

Thermal radiation is that electromagnetic radiation emitted by a body as result of its temperature. There are many types of electromagnetic radiation; thermal radiation is only one. Regardless of the type of radiation, we say that it is propagated at the speed of light 3×10^8 m/s.

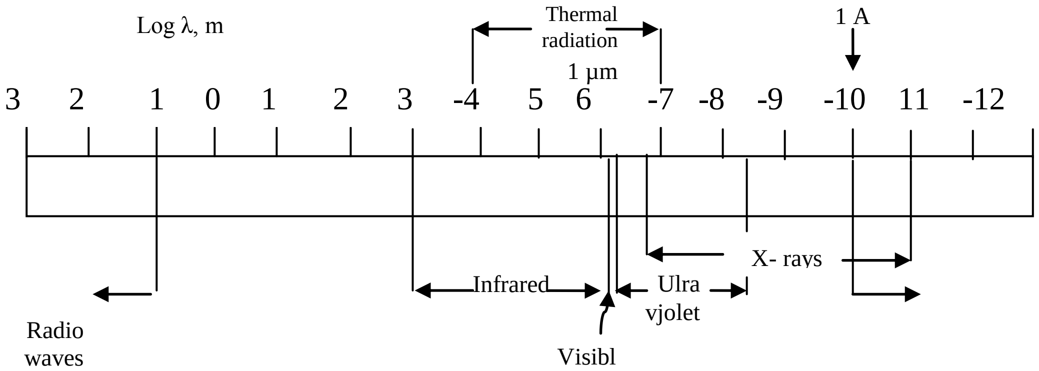

Figure (1) Electromagnetic spectrum

When the energy density is integrated over all wavelengths, the total energy emitted is proportional to absolute temperature to the fourth power.

$$E = \varepsilon\sigma A T^4$$

This eq is called the Stefan- Boltizmann Law, Eb is the energy radiated per unit time and per unit area by the ideal radiator, and σ is the Stefan- Boltizmann constant, which has the value
$\sigma = 5.669 \times 10^{-8}\ W/m^2K^4$
Where E_b is in watts per square meter and T in degrees Kelvin.

When radiant energy strikes a material surface, part of the radiation is reflected, part is absorbed, and part is transmitted, a show in fig (2). We define the reflectivity ρ as the fraction reflected, the absorptivityα as the fraction absorbed, and the transmissivity τ as the fraction transmitted. Thus

$$\rho + \alpha + \tau = 1$$

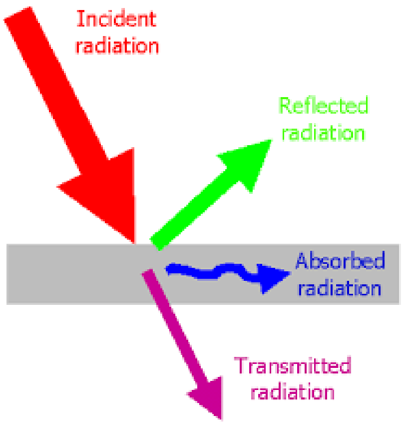

Figure (2) sketch showing effects of incident radiation

The emissive power of a body E is defined as the energy emitted by the body per unit area and per unit time. Assume that a perfectly black enclosure is available. This enclosure will also emit radiation according to the T^4 law. Let the radiant flux arriving at some area in the enclosure be q_i W/m^2. Now suppose that a body is placed inside the enclosure and allowed to come into temperature equilibrium with it. At equilibrium the energy absorbed by the body must be equal to the energy emitted, at equilibrium we may write
$EA = q_i A \alpha$
If we now replace the body in the enclosure with a blackbody of the same size and shape and allow it to come to equilibrium with the enclosure at the same temperature

$E_bA=q_iA(1)$

Since the absorptivity of a blackbody is unity. If eq $EA=q_iA\alpha$ is divided by

$E_bA=q_iA(1)$

$$\frac{E}{E_b}=\alpha$$

And we find that the ratio of the emissive power of a body to the emissive power of a blackbody at the same temperature is equal to the absorptivity of the body. This ratio is defined as the emissivity ε of the body,

$$\varepsilon=\frac{E}{E_b}$$

So that $\varepsilon=\alpha$
They represent the integrated behavior of the material over all wavelengths. Real substances emit less radiation than idea black surfaces as measured by the emissivity of the material. In reality, the emissivity of a material varies with temperature and the wavelength of the radiation.
Then

$q=\varepsilon\sigma AT^4$.

C. Description of Instrument:

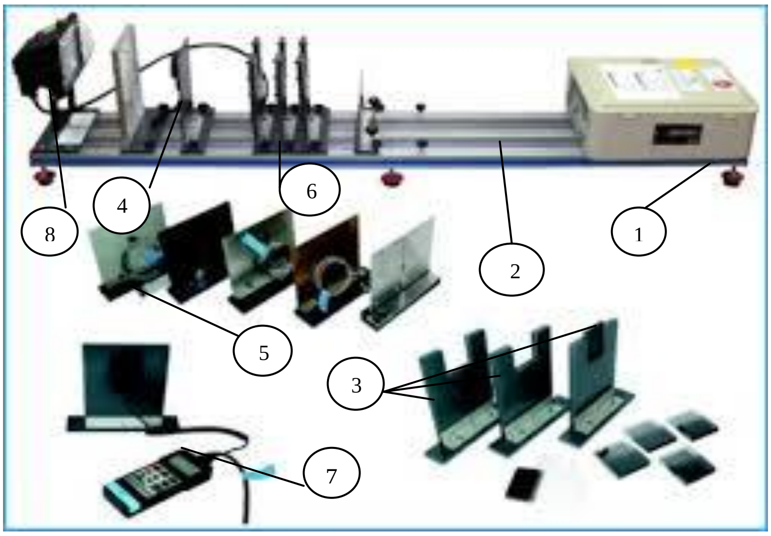

Figure (3) Thermal Radiation Instrument

1. Heater.
2. Control ruler (for controlling in width of the light).
3. Filters (radiation shield or dark body, mid dark body, diaphanous)
4. Thermal receiver
5. Radiation receiver
6. Metals (black, brass, aluminum).
7. Lox meter.
8. projector

Apparatus
TXC/RC. Radiation Heat Conduction Module:

Bench top unit designed to demonstrate the laws of radiant heat transfer and radiant heat exchange. It basically consists in two independent parts. One of the parts is for the light radiation experiments and another part is for the thermal radiation experiments.
The elements provided with the unit allow making the measuring of the temperature, radiation, intensity light and the power in the resistance or bulb. Anodized aluminum structure and panels in painted steel.
This unit consists on a metal plate with a resistance at one side and a lamp in another side. Lengthwise of the metal plate you can place the elements supplied with the unit.

Heating resistance (ceramic resistance: 500W), computer controlled.

- 7temerture sensors.
- Power measurement from the computer(PC)
- Radiation measurement from the computer (PC).
- Cables and Accessories, for normal operation.
  This unit is supplied with 8 manuals: Required Services, Assembly and installation, Interface and Control Software, Starting– up, Safety, Maintenance, and Calibration & Practices manuals.
- Computer Control Software:
  Computer Control+ Data Acquisition +Data Management Software for Radiation Heat Conduction Module (TXC/ RC).

d. Procedure:-

(Heat Exchange between two black bodies)

1. Connect the SCADA program TRTC.
2. Verify that all the temperature sensor and that the heating resistances have been connected.
3. Fix the distance between the first black plate and the heating resistance at 5cm
4. Fix the distance between the first black plate and the second black plate of 5 cm.
5. Fix a power for the heating resistance 50% power.
6. Wait until the system temperature in the plates reaches stable value. Take the measurement from the radiometer.
7. Repeat the previous step for a value of the power in the heating resistance of 60%, 70%, 80%, 90%.
8. Change the distance between two plates (5cm, 7cm, 9cm, 11cm) and repeat all the previous steps.

%Power		T_1	T_2	q
	D = 5cm			
	D = 7cm			
	D = 9cm			
	D = 11cm			
	D = 5cm			
	D = 7cm			
	D = 9cm			
	D = 11cm			

e. Calculations:

Determine heat exchange between two black plates Q by using:

$$q = \sigma A\left(T_1^{\,4} - T_2^{\,4}\right)$$

T_1: temperature of the first black plate (K).
T_2: temperature of the second black plate (K).
A: area of plate= 0.026 m^2

And then plot the heat exchange between two black plates versus distance between these plates at different power: