Infrared radiation, sensor, source and infrared camera measurement

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Abstract: The article deals with the infrared radiation source EK-8520, ability to measure using a thermocouple TP334 and temperature by thermal imager for calculating spectral range. It prepares the theoretical and practical bases for testing infrared radiation detectors for security technologies.

Key-Words: IR radiation, sensor, emissivity, detector, security technology

1 Introduction

The heat-emitting sources are characterized by broad spectral range, where the spectral maximum is shifting to the rising temperature resource from the far-infrared region to region near the visible spectrum. The aim is to measure the temperature of the source of thermal imager, to determine the spectral maximum amount of energy emitted by source of radiation in our case, the EK-8520 produced by Helioworks, TP334 evaluate the sensitivity of the sensor on this radiation and create the conditions for measurement, especially in the spectral range of about 9 mm.

2 Problem Formulation

We have to realize measure workplaces with instruments for measuring of radiation and optical properties of sources and sensors.

2.1. Workplace with thermal imager.

The workplace is symbolically illustrated in Figure 1 and consists of a regulated DC power supply 2 with the possibility to limit the maximum current to avoid damage of the IR radiation source. In the brass holder 3 is placed source IR 8520 EC so that the emitted infrared radiation reflected from the inner gold- plated dish so that is not overshadowed by brass holder and is all directed to the brass plated tube 4 in the direction of the IR camera. The metal tube is 10 cm long, the camera is placed at 15 cm distance from the source of the EC 8520.

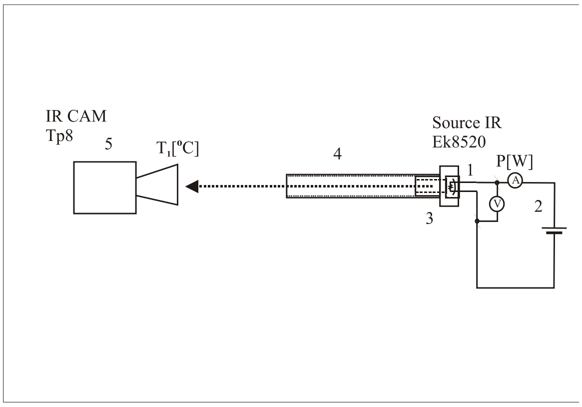

Fig. 1 measuring workplace 1 with thermal imager

Workplace 2 is symbolically illustrated in Figure 2, consists of a source of right and on the left is added termopile sensor TP334 - 6 in brass housing, apparatus for measuring very small voltage - 7, the thermistor resistance measurements TP334 - 8, and then integrated thermometer T1, T2, T3, which are routed over the block 9 to the PC via USB, where are stored all the measured values.

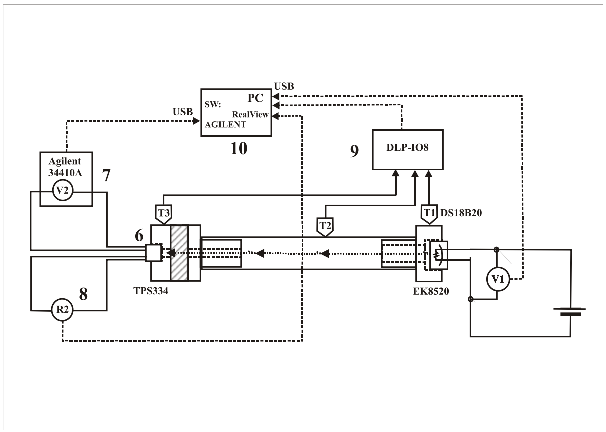

Fig. 2 measuring workplace 2 with thermopile sensor and source of radiation.

Stefan-Boltzmann law is energy basic law, which describes transmission energy of absolutely black body

$$Q_0 = H_0 \,.\, S_1 = \delta_0 .\, T^4 .\, S_1 \qquad (1)$$

where H_0 is all intensity of radiation (W/m^2)

S_1 is square of body

T is absolute temperature of body

δ_0 is Stefan-Bolzman konstant

$$\delta_0 = 5{,}37032 \,.\, 10\ \text{-}8\ (W\, m^2\, K^{-4}) \qquad (2)$$

The body is not absolutely black but gray in real situation

$$Q_B = \delta_0 \,.\, S_1 .(\varepsilon_1 \,.\, T_1^4) \qquad (3)$$

ε_1 is coefficient of emissivity of body [1]

Energy coming into IR camera lens is directed by parabola and tube

$$Q_{B1} = \delta_0 \,.\, S_1 .(\varphi_1 \,.\, \varepsilon_1 \,.\, T_1^4) \qquad (4)$$

φ_1 is angle coefficient

The maximum amplitude of the wavelength according to the Wien's displacement law is

$$\lambda_{max} = b / T \qquad (5)$$

T is absolute temperature of black body
b is constant of proportionality b = 2,898 .10^{-3} mK

3 Problem Solution

Measured values for filter 1 for measuring temperatures in the range - 20 to + 250 ° C, emissivity ε1 = 0.7 for kanthal wire are placed in table 2. The values was measured for IR emitters without windows and surface of the inner tube flat S1 = π. D2 / 4 = 2.54 cm^2.

The values for filter 2 with range IR camera for the + 200 to + 800 ° are in table 3. The values of Q_B and λ_{max} are then calculated according to formulas (3) and (5).

Table 2 Measured values temperature for filter 1

Filter	Voltage	Current	Power	Temp	EmitEn	$\lambda_1$max
1, 2	U[mV]	I[mA]	P[W]	T1[^{o}C]max	Q_B [W]	[µm]
1	321,2	140,0	0,0450	24,60	0,0794	9,733
1	404,0	170,0	0,0687	25,60	0,0805	9,700
1	554,0	240,0	0,1330	31,30	0,0868	9,518
1	748,0	320,0	0,2394	35,60	0,0918	9,386
1	986,0	430,0	0,4240	45,80	0,1045	9,086
1	1 149,0	500,0	0,5745	58,10	0,1216	8,748
1	1 580,0	690,0	1,0902	75,60	0,1494	8,309
1	1 831,0	790,0	1,4465	88,90	0,1736	8,004
1	2 108,0	900,0	1,8972	110,30	0,2184	7,558
1	2 949,0	1 260,0	3,7157	140,60	0,2960	7,004

Table 3 Measured values temperature for filter 2

Filter	Voltage	Current	Power	Temp	EmitEn	$\lambda_1$max
1, 2	U[mV]	I[mA]	P[W]	T1[^{o}C]max	Q_B [W]	[µm]
2	1 412,0	610,0	0,8613	281,80	0,9580	5,222
2	1 674,0	730,0	1,2220	315,50	1,2128	4,923
2	1 879,0	810,0	1,5220	355,40	1,5766	4,611
2	2 146,0	930,0	1,9958	404,70	2,1326	4,275
2	2 361,0	1 020,0	2,4082	456,60	2,8646	3,971
2	2 473,0	1 070,0	2,6461	482,30	3,2899	3,836
2	2 878,0	1 240,0	3,5687	528,60	4,1737	3,615
2	3 253,0	1 390,0	4,5217	574,30	5,2098	3,420
2	3 252,0	1 390,0	4,5203	578,10	5,3038	3,404

The temperature dependence of the input power the source of infrared radiation EK 8320 is shown on

ISBN: 978-1-61804-004-6

Figure 3 and the dependence of the maximum wavelength of the source temperature on Figure 4.

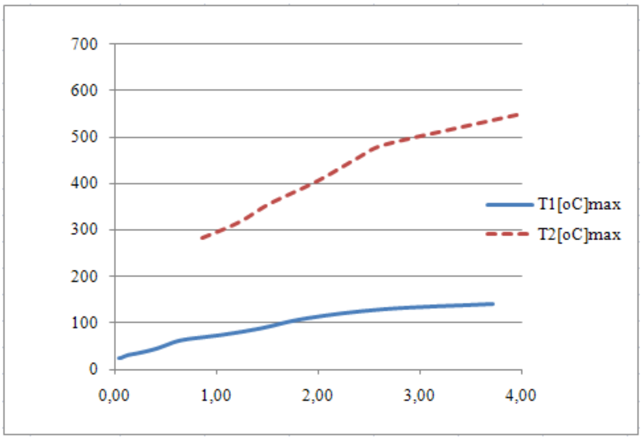

Fig. 3 Dependency T=f(P) for filter 1 a 2 of IR camera

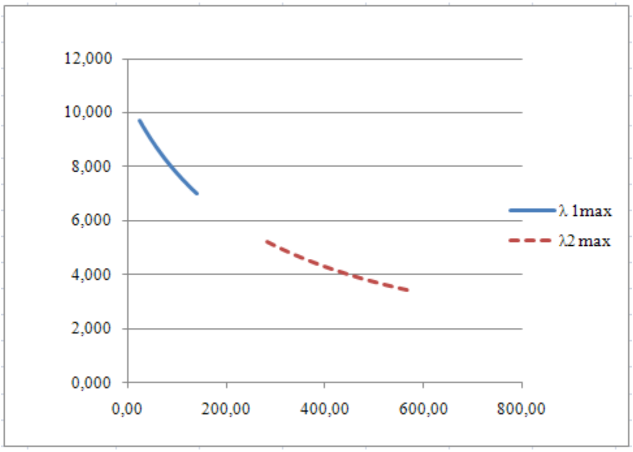

Fig. 4 Dependency λ_{max}=f(T) for filter 1 a 2 of IR camera

4 Conclusion

The graph in figure 3 shows that the quantity of heat energy that passes through the filter 1 is less than the amount of heat that passes through the filter 2, which is mainly due to characteristics of the filter of IR camera. Simultaneously Q_B energy radiated at low emitter power consumption is lower, that is caused that a certain quantity of heat energy of kanthal spiral at lower temperatures is taken into surround and absorbed into the brass holder.

The graph in figure 4 shows the dependence of λ max = f (T) and demonstrate, that at lower temperatures the maximum wavelength is shifted to the area about 9 mm, while at temperatures above 400 ° C is a maximum range below 4 mm. This is especially useful for security applications, where we need accurately define the characteristics of the IR source and then we can use it for testing of PIR detectors and directional characteristics statically and dynamically with possibility measuring of transition action.

References:

[1] HRUŠKA, F., The Specific Measurement of Medium Radiant Temperature, *Proceedings of the 14th International Conference on Process Control ´03*, p. 269., 2003, ISBN 80-227-1902-1