การทวนสอบเครื่องวัดอุณหภูมิชนิดอินฟาเรดด้วยเพลเธียร์เทคนิค
Verification of IRT with the peltier technique

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บทคัดย่อ

ปัจจุบันความต้องการใช้เครื่องวัดอุณหภูมิชนิดอินฟาเรดเพิ่มมากขึ้นอย่างต่อเนื่อง โดยเฉพาะอย่างยิ่งที่ใช้กันอย่างแพร่หลาย เช่น ตามจุดคัดกรองและสถานบริการด้านการสาธารณสุขเพื่อป้องกันการแพร่ระบาดของเชื้อไวรัสโควิด-19 แต่ไม่ค่อยมีความน่าเชื่อถือสาเหตุจากมีค่าความคลาดเคลื่อนสูง ซึ่งมีความเสี่ยงต่อการแพร่ระบาดของเชื้อไวรัสโควิด-19 เพิ่มมากขึ้น การทวนสอบเครื่องวัดอุณหภูมิชนิดอินฟาเรดดังกล่าวด้วยแบล็คบอดี้อาจทำให้ค่าใช้จ่ายสูงและค่าความแม่นสูงเกินความจำเป็น เทคนิคการทวนสอบเครื่องวัดอุณหภูมิชนิดอินฟาเรดด้วยชุดสมาร์ทคิทซึ่งสามารถทวนสอบเครื่องวัดอุณหภูมิชนิดอินฟาเรดตามมาตรฐานASTM E1965-98 [1] ช่วงการวัดตั้งแต่ 36°C ถึง 39°C และตามช่วงการยอมรับ ±0.3°C อีกทั้งยังเพิ่มประสิทธิภาพและความน่าเชื่อถือของเครื่องวัดอุณหภูมิชนิดอินฟาเรดด้วยเสถียรภาพดีกว่า

Abstract

Recently, the demand for infrared thermometers (IRT) is increasing continuously. They are widely used in many applications, such as measuring temperature at the screening points and public health facilities to prevent the spread of the COVID-19 virus. However, it is not reliable due to their limit of tolerance, which results in an increased risk of the epidemic of the COVID-19 virus.Verifying those IRTs with a black body can be costly and unnecessarily for high accuracy. Techniques for verifying the IRT with smart kits are detailed in the document of ASTM E1965-98 [1]. By using these techniques for the smart kit, the measuring range with the accuracy of ± 0.3°C can be cover up the temperature of 36°C to 39°C. These methods of verification also improve the efficiency and reliability of infrared thermometers.

คำสำคัญ: ชุดสมาร์ทคิท เครื่องวัดอุณหภูมิชนิดอินฟาเรด เพลเธียร์เทคนิค การทวนสอบ แบล็คบอดี้
Keywords: Smart kits, Infrared thermometer, Peltier technique, Verification, Black body

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1. (Introduction)

1.1 Introduction

At the present, non-contact infrared thermometers (IRT) are widely applied for measuring temperature at the screening points and hospitals, because they are both more convenient and safer in using for everyone, especially when they are used for the measuring of patient temperature. Although those IRTs are more convenient and safer in use than a simple thermometer, there are some errors in the measurement results of the devices. Unfortunately, each one of IRT is not reliable in measurement and conforms specification, which may cause errors in the risk of diagnosis.

The IRT needs to calibrate or routine performance check as the interval program, in order to correct and prove within their tolerance of specification. Generally, the IRT is necessary calibrated by using black body source in the metrological laboratory. Blackbody source or Black body knows well as the measurement standard used for calibrating non-contact infrared thermometer.

Practically, it is not possible to do this, due to a large number of IRTs. Moreover, it is not only the high calibration cost, but service period of calibration might also take a long time. Verification is the process of establishing the accuracy, or validity of IRT. The verification is a good way, good solution, and more suitable for solving this condition.

This paper will present the IRT verification technique by using a smart kit, which was built by the principle of the Peltier effect technique. The Peltier semiconductor type generates warm temperature on one side of its surface and another side of its surface generates cool temperature, when apply electrical voltage to Peltier plate. The smart kit for IRT produces a warm side to create temperature within controlling by the enhance microcontroller at the temperature range of 36°C to 39°C, according to ASTM E1965-98(2016), which their measurement stability is better than ± 0.3°C. This solution is equivalent to the black body source for solving the IRT reliability. By using this new device, insufficiency of the IRT calibration service would be also solved. The next project would develop the verification of IRT face recognition type.

1.2 Principles and designs

1.2.1 Blackbody source

The blackbody [2] source is an electromagnetic radiation system that is emitted by an object that is in thermodynamic equilibrium. An object is considered an ideal of perfect blackbody when it absorbs all of the incoming light and does not reflect any. Blackbody source or Blackbody is known well as the measurement standard used for calibrating non-contact infrared thermometer (IRT). Generally, the blackbody sources consisting of a black target plate as shown in the Fig. 1 can be heated to specific temperatures, and they have a characteristic of very high accuracy with the emissivity $\varepsilon = 1$.

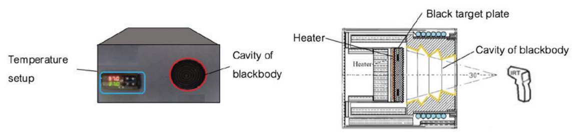


Fig.1 Black body source and basic structure

1.2.2 Smart kit for IRT designs

The design of Smart kit for IRT is as following the ITS -90 traceability of all thermometers, both contact and non-contact thermometer. The smart kit for IRT is traceable to the SPRT thermometer, as shown in Fig. 2.

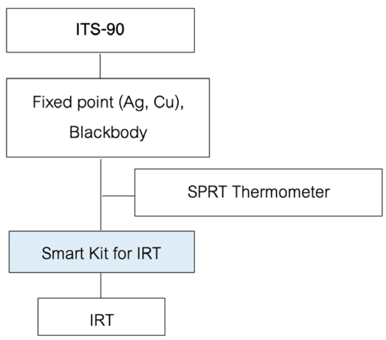


Fig. 2 The traceability of thermometer

Typically, the Peltier effect [3] is multi-junctions in series of n-type and p-type semiconductor, through which a current is driven. Due to the Peltier effect, some of the junctions absorb heat or lose heat (cold side) on ceramic surface, while others release heat or gain heat (hot side) on ceramic surface, as shown in Fig. 3. Thermoelectric heat pumps exploit this technology, such as Peltier devices found in refrigerators.

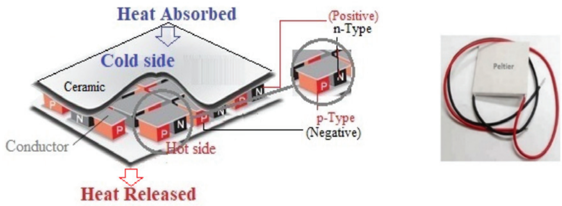


Fig. 3 Principle of Peltier effects and Peltier device

The design of smart kit for IRT uses the principle of Peltier effect. It has just only used hot side junction to create temperature instead of the heater. In order to save the electrical power and to control temperature, a microcontroller (Arduino) [4] and software are used in the design.

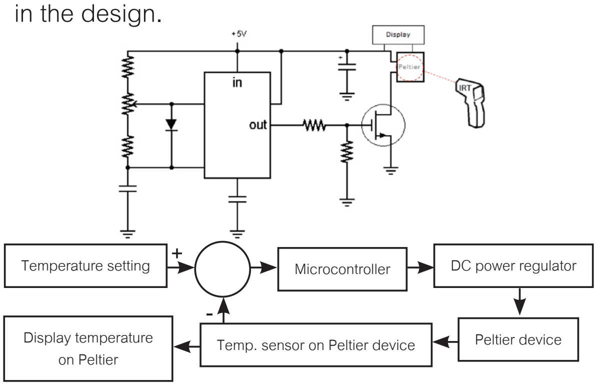


Fig. 4 The schematic diagram and flow chart of smart kit for IRT

2. Experimental methods

An experiment was carried out in order to fulfil 2 objectives. The first objective was to verify the smart kit by comparing with black body in term of controlling a heat radiation. This objective was done by using IRTs, which were used in Thailand as artefacts. The second objective was to verify IRT performance. By comparing temperature measured from IRT with the heat sources radiated from the smart kit and the black body, a performance of IRT can be verified.

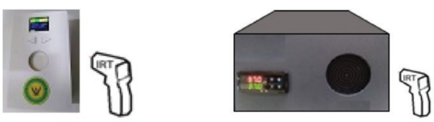


Fig. 5 IRT to measure temperature at heat radiation of the smart kit and black body.

Before the experiment was done, the smart kit was calibrated by the thermometer with thermocouple. The processes of experiment were carried out as follows.

- Setting the heat radiation of the smart kit and the black body was at 36°.
- IRTs were used to measure temperature at the heat radiation of both sources (Fig. 5).
- Temperatures measured from IRTs and both sources were recorded.
- The processes of setting the heat radiation of both sources, measuring and recording temperature of IRTs were carried out for the temperature at 37°, 38° and 39°, which were called as 1 cycle of measurement.
- The measurements of this experiment were conducted for 3 cycles.

3. Results and discussion

3.1 Experimental results

Results of the experiment were showed on table 1, Table 2 and graph 1

Table1 Average of temperature measured from IRT

T_s(°C)	IRT 1		IRT 2		IRT 3
	T_{irs}(°C)	T_{irb}(°C)	T_{irs}(°C)	T_{irb}(°C)	T_{irs}(°C)
36.0	36.8	36.8	36.3	36.3	36.0
37.0	37.0	37.0	36.6	36.5	37.0
38.0	38.4	38.5	36.7	36.7	38.0
39.0	39.8	39.8	37.2	37.2	39.1

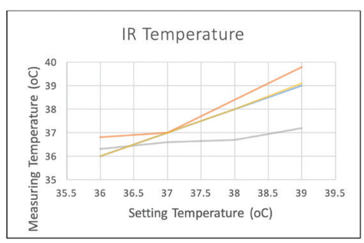
Remarks: 1. IRT 3 cannot be used with the black body in the mode of body.

2. Measurement uncertainty [5] of T_{irs} is 0.87 °C and T_{irb} is 0.42 °C approximately at confidential level of 95%.

Which T_s is the temperature setting from the smart kit and the black body,

T_{irs} is the average temperature measured from an IRT used with the heat radiation of the smart kit,

T_{irb} is the average temperature measured from an IRT used with the heat radiation of the black body.



Graph 1: Temperature measured from IRT: Blue line = ideal, Brown line = temperature from IRT 1, Purple line = temperature from IRT2 and Green line = temperature from IRT 3.

Table 2 EN Ratio for verification of the smart kit

T_s(°C)	EN Ratio	
	IRT 1	IRT 2
36.0	0	0
37.0	0	0.11
38.0	0.11	0
39.0	0	0

3.2 Discussion

One of the objectives of the experiment is to verify the smart kit. To do this, temperatures measured from the IRT using the smart kit as the heat radiation was compared with that using the black body as the heat radiation. The comparison is carried out in term of the EN Ratio. This EN Ratio was calculated by the equation of [6]

$$EN = \left| \frac{T_{irb} - T_{irs}}{\sqrt{U_{irb}^2 + U_{irs}^2}} \right|$$

, which U_{irb} and U_{irs} are measurement uncertainty of T_{irb} and T_{irs}, respectively.

By using data from table 1, the EN Ratio was calculated as shown in Table 2. Since the EN Ratio is less than 1, so the experimental results distinctively verify that the smart kit gives the good performance according to the black body.

To verify quality of IRTs, these instruments will measure its temperature accuracy, since the standard ASTM E1965-98 [1] assigns that IRT used for measuring skin temperature must accurate within ± 3 °C. The Data from table 1 and graph 1 clearly demonstrate that the accuracy of the IRT 1 corresponds with that standard only at the temperature of 37 °C while that of the IRT 2 corresponds with the standard only at the temperature of 36 °C. From observation, hence both instruments, IRT 1 and IRT 2, are unqualified to be used anymore.

4. Conclusion

This paper has described the principle of the smart kit for an IRT. Its performance was successfully verified by the experiment results in term of EN Ratio. The results also shows that IRT, which was used in the present, might be unreliable.

5. Acknowledgement

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