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Design Specification of a Self-generating Infrared Temperature Gun

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Abstract

The hand-held infrared thermometer is widely used in hospitals, stations, families and other places. There are problems such as frequent charging or battery replacement. In view of the above situation, the team designed a self-generating temperature measuring gun based on electromagnetic induction. The kinetic energy is converted into electric energy by shaking the temperature measuring gun, so that the temperature measuring gun has the advantages of being used at any time, waterproof and resistant to falling. The problem that the battery has no electricity when the battery is in urgent need is solved. At the same time, it avoids the environmental pollution caused by the extensive use of disposable batteries and contributes to the cause of low carbon emission reduction. Promote the vigorous development of human health.

Keywords

Self-generation; electromagnetic induction; infrared thermometry; energy saving and emission reduction.

1. Introduction

Temperature measuring equipment, as a necessary tool for human beings to quantify "temperature", was invented by Galileo in 1593.From the mercury thermometer made by French scientist Brio in 1654 to the birth of the first infrared thermometer in 1988,It has undergone significant technological progress. With the continuous development of integrated circuits and integrated sensors, the infrared thermometer is gradually miniaturized and its accuracy is continuously improved. It has been widely used in industrial detection, fire prevention and family temperature detection. Especially after the epidemic of novel coronavirus, the forehead temperature gun and temperature measuring door based on infrared thermometry have been widely used.

In the announcement issued by the Ministry of Ecology and Environment in 2017, it is clear that "from January 1, 2026, the production of mercury-containing thermometers and mercury-containing sphygmomanometers will be prohibited". In this context, infrared thermometry equipment is booming.However, it still needs external power supply, and the huge market will consume a large number of batteries and cause environmental pollution.This new type of self-generating temperature measuring gun adopts electromagnetic induction power generation technology.It will effectively solve the problems of low convenience and environmental pollution caused by waste batteries in traditional temperature measuring guns.It can be widely used in families, schools, hospitals, public places and other fields.Provide strong support for epidemic prevention and control, disease surveillance, etc.

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2. Domestic and international status

2.1. Thermometry technology

At present, thermometry technology at home and abroad can be divided into two categories: contact and non-contact.Contact temperature measurement technology mainly includes sensor temperature measurement and liquid thermometer;Non-contact thermometry technology mainly includes infrared thermometry technology, RFID wireless thermometry technology, surface acoustic wave temperature sensing technology.The thermometry sensor based on infrared radiation has the advantages of low cost, simple thermometry principle, no contact and high accuracy.It is in line with the positioning and application scenarios of this temperature gun.

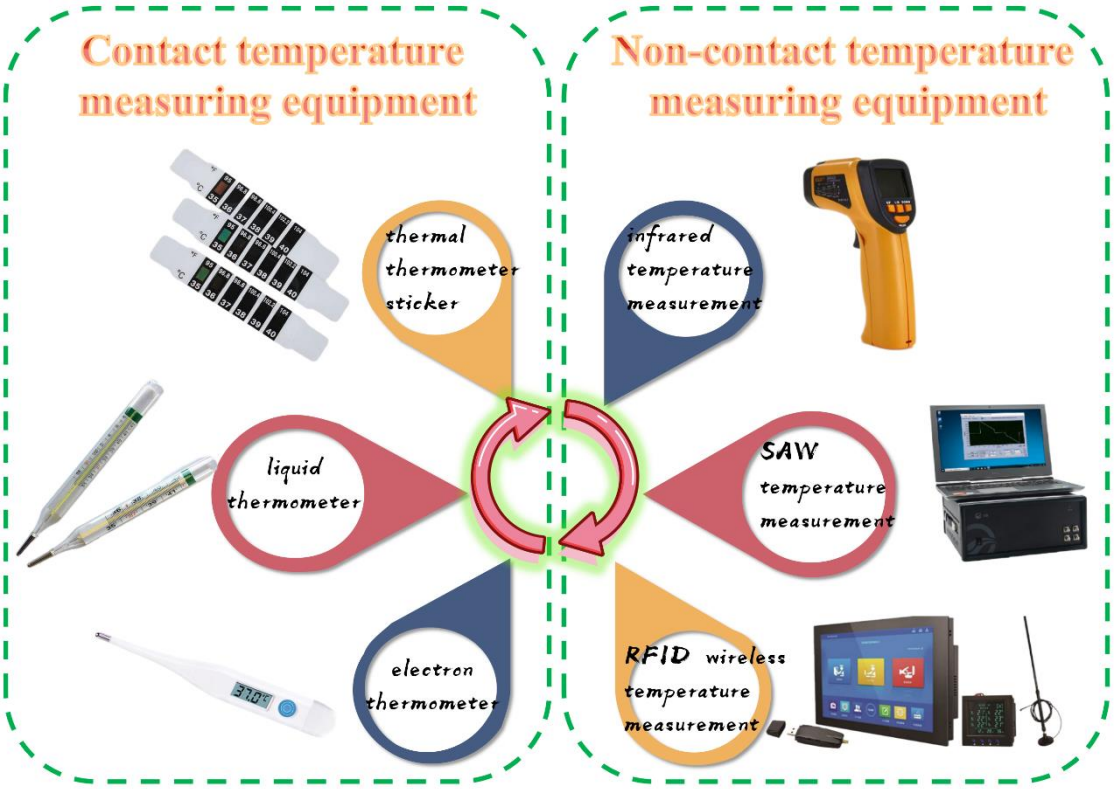

Fig. 3 Classification of Temperature Measurement Technology

2.2. Self-generation technology

Self-generation technology refers to the technology of capturing and converting usable forms of energy from the surrounding environment to power equipment.At present, there are pressure power generation, photovoltaic panels, nano-friction power generation and other technologies.However, there are some problems such as immature technology, high manufacturing cost and small power generation.In terms of power generation equipment, domestic and foreign self-generating products cover many fields.Including fitness equipment, smart home, outdoor equipment and so on.Uch as a self-generating spinning bike, a self-generating flashlight, a self-generating wireless switch and a self-generating intelligent door lock.The self-generating flashlight which generates electricity by shaking provides a good design idea for the product.

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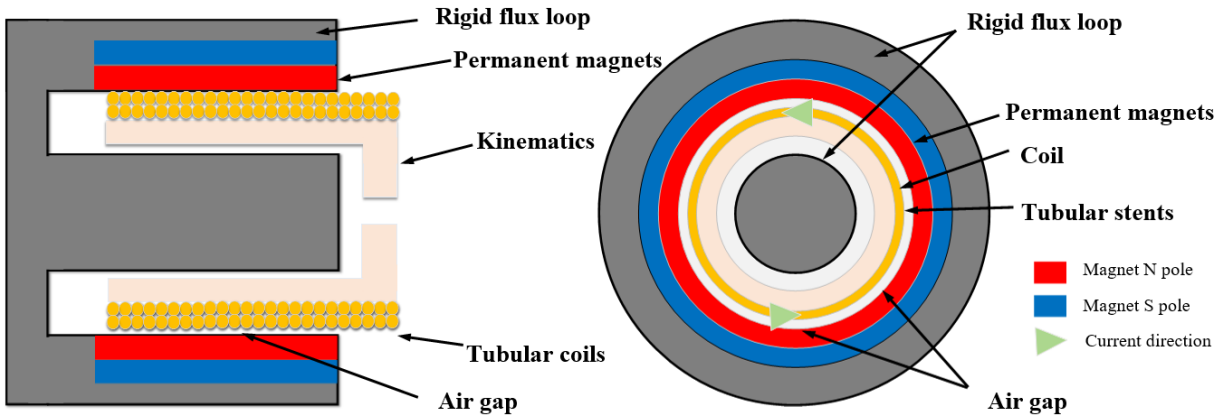

Fig. 4 Schematic diagram of permanent magnet cutting magnetic induction line for power generation

3. Feasibility analysis

3.1. Thermometry method

Like other organisms, the human body radiates infrared energy around itself, with a wavelength of 9-13 μm.It is in the near infrared band of 0.76-100 μm. Ince light in this wavelength range is not absorbed by air, that is,The amount of infrared radiation from the human body has nothing to do with the environmental impact, but is related to the amount of energy contained and released by the human body.Therefore, the surface temperature of the human body can be accurately measured only by measuring the infrared energy radiated by the human body itself.

Fig. 5 thermometry of thermometry gun

3.2. Energy supply

The product supplies power to the thermometry induction module and other application modules by using the permanent magnet cutting coil to generate electricity,The self-supply of the energy and the economical utilization of the resources are realized, and meanwhile, the storage battery is arranged to store excessive energy,The power supply conditions of the system are met, and the effects of energy conservation and emission reduction are achieved.

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4. System structure block diagram

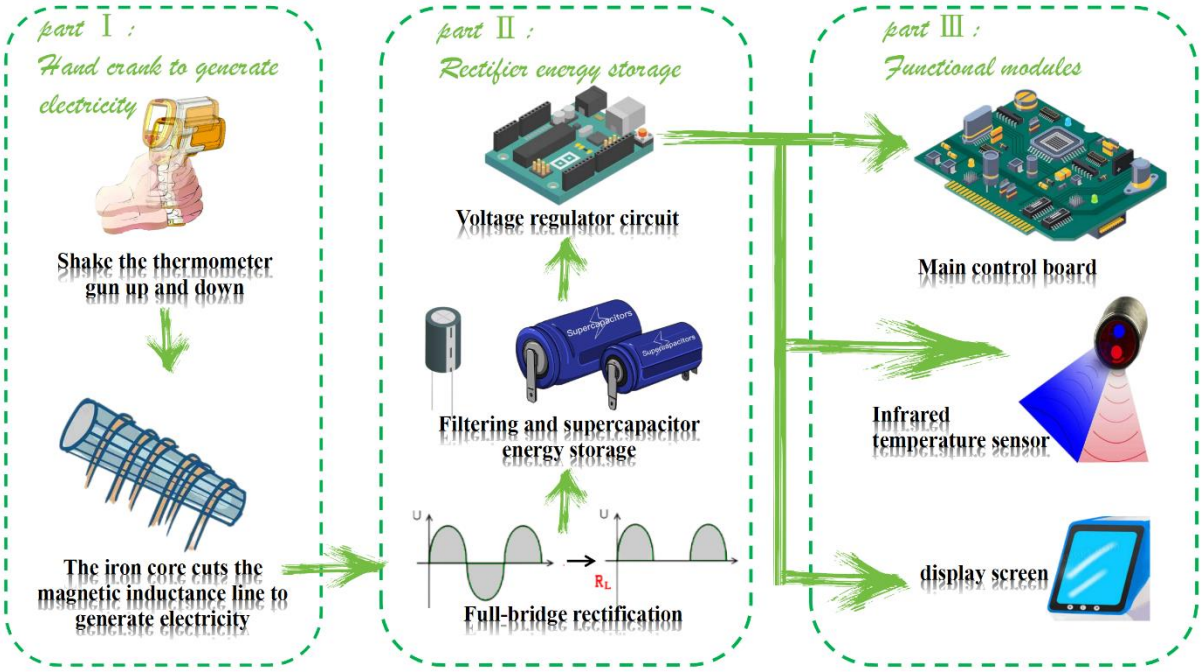

Figure 6 Product system block diagram

5. Model design and structure composition

5.1. Equipment appearance design

The overall size of the multifunctional temperature measuring gun equipment is 20 cm *10 cm * 5 cm, and it is equipped with a liquid crystal screen and an infrared generator.The grip is wrapped by the keel hand glue, so that the friction force between the grip and the palm is increased, and a user can use the grip more conveniently and easily.The volume of the whole equipment is small, and the effect of portable use is realized on the basis of meeting the placement of each internal module.

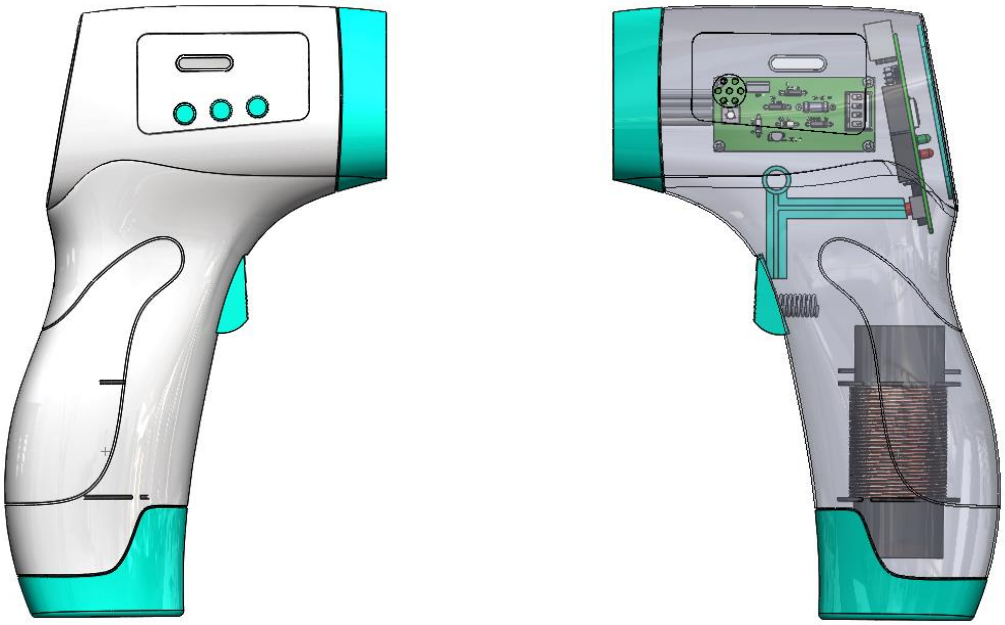

Fig. 7 Model Diagram of Multifunctional Temperature Measuring Gun

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5.2. Internal structure of equipment

The interior of the equipment is designed in a hierarchical way.An infrared thermometry module, an information storage module and a permanent magnet cutting power generation module are sequentially arranged from top to bottom.A swaying product and a permanent magnet cutting coil are used for generating power to supply energy to the system, and an infrared thermometry module is used for measuring the temperature of a human body.The data obtained by each thermometry is recorded and stored in the information storage module.The USB port is connected with a computer, on the one hand, the data is read, and on the other hand, the 5V voltage of the USB is used for supplying power to the main control chip to read the data.

6. Working principle

6.1. Electromagnetic power generation

The device adopts an electromagnetic power generation technology,The system consists of spring, magnetic rod (input part), controller, rectifier, battery (output part) and other devices.A user shakes the temperature measuring gun to force the permanent magnet to cut the coil, so that the kinetic energy is converted into electric energy for the temperature measuring gun to use.Considering the extraction and storage of electric energy, here the permanent magnet is used as a moving part, and the coil assembly is used as a "stator".And then the electric quantity is led out to the temperature measuring gun or stored in the storage battery.It realizes zero pollution power generation and conforms to the new concept of saving resources, low carbon and environmental protection in today's society.

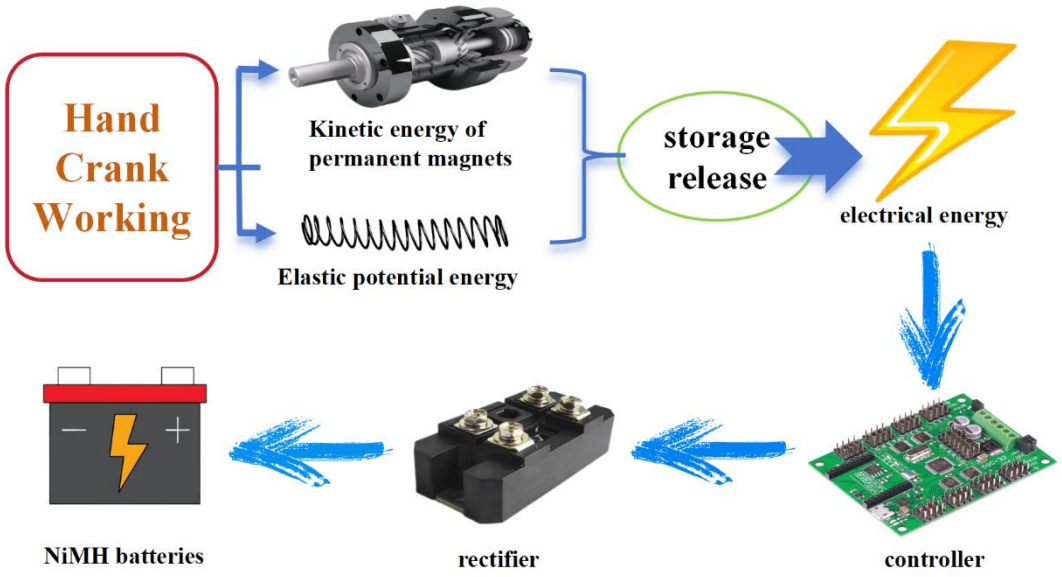

Fig. 8 Schematic Diagram of Device System Scheme

6.2. Infrared thermometry

The temperature measuring principle of the infrared thermometer is the blackbody radiation law,All objects above absolute zero in nature are constantly radiating energy outward.The amount of energy radiated by an object and its distribution according to wavelength are closely related to its surface temperature.The higher the temperature of an object, the stronger the infrared radiation it emits.Therefore, by measuring the infrared energy radiated by the object itself, its surface temperature can be accurately determined.

The infrared thermometer is composed of optical system, photoelectric detector, signal amplifier, signal processing and display output.During temperature measurement, the optical

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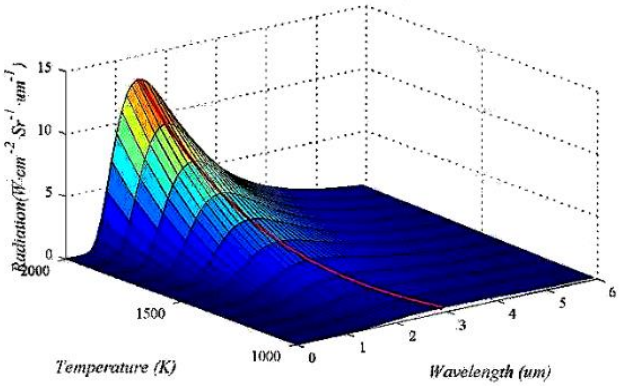
system converges the infrared radiation energy of the target in the field of view of the thermometer;The infrared energy is focused on the photodetector and converted into a corresponding electrical signal that passes through an amplifier and signal processing circuitry,The temperature value of the measured target is displayed on the display screen after being corrected according to the algorithm in the instrument and the target emissivity.



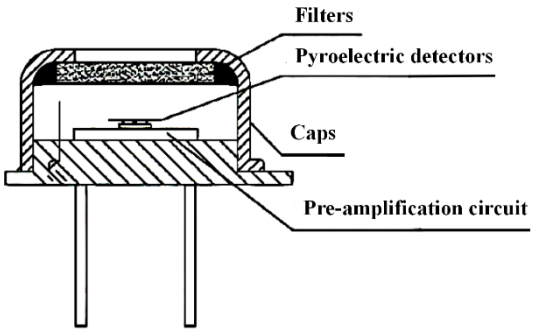


Figure 9 Blackbody spectral radiance map at different temperatures (left) Figure 10 Pyroelectric infrared sensor (right)

7. Theoretical calculation

7.1. Selection of electromagnetic power generation materials

For an electromagnetic induction generator for ambient vibration energy harvesting,Its energy collection efficiency is related to the magnetic strength, corrosion resistance and thermal stability of the permanent magnet.Therefore, neodymium iron boron (NdFeB) with strong magnetic energy is the best choice for most permanent magnets of environmental energy collectors.Therefore, the NdFeB magnet will be selected as the permanent magnet material of the generator in the electromagnetic power generation structure of this paper.

Table 1 Composition and Characteristics of Permanent Magnet

Magnet	Main components	Characteristic
NdFeB	Neodymium (Nd), Iron (Fe), Boron (B), etc.	strong magnetic force, poor corrosion resistance, poor thermal stability
SmCo	Samarium, Cobalt	moderate corrosion resistance, good thermal stability
Ceramic	Iron oxide (Fe_2O_3), Barium oxide(BaO), Strontium Oxide (SrO), etc.	weak magnetic force , good corrosion resistance, poor thermal stability
AINiCo	Aluminum (Al), Nickel (Ni), Cobalt (Co), etc.	common magnetic force , good corrosion resistance, good thermal stability

7.2. Electromagnetic power generation capacity

According to the magnetic field distribution of permanent magnets, the team designed a permanent magnet with a height of 30 mm, a diameter of 30 mm, an inner diameter of 31 mm and an outer diameter of 33 mm.The height of the coil winding is 30 mm, the thickness is 6 mm, the wire diameter is 0.1 mm, and the number of coil turns is 20911.

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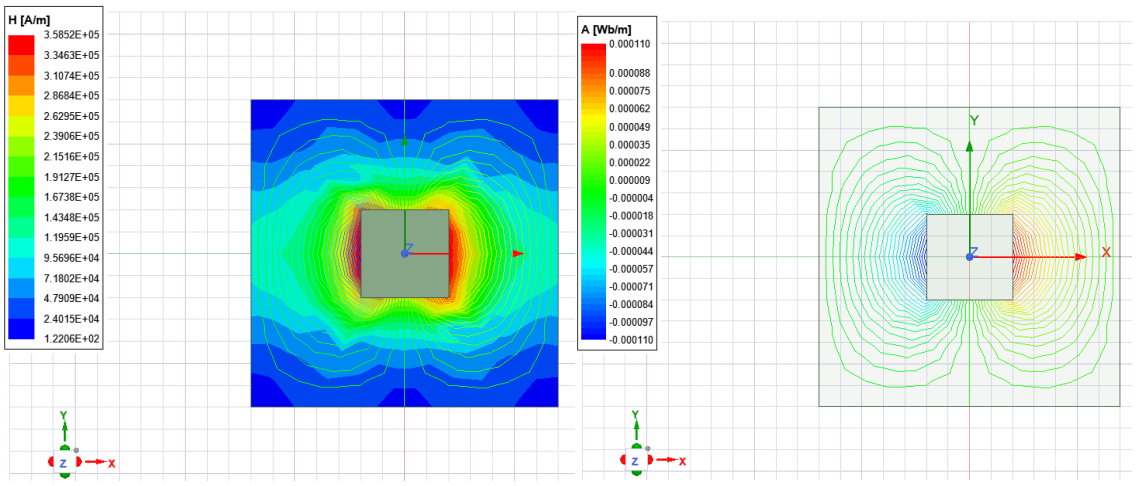

Fig. 11 Distribution of magnetic field intensity

Under the condition that the vibration speed of the permanent magnet is 55 mm · s^{-1} and the vibration amplitude is 30 mm, the magnetic field intensity at any point is:

$$\vec{H}_m = -\nabla\varphi_m = \frac{B}{\mu_0} = \frac{1}{4\pi\mu_0}\left(\iiint_V \frac{-b \pm \sqrt{b^2-4ac}}{2a}\frac{\rho_m \vec{R}}{R^3}dV + \oiint_S \frac{\rho_{ms}\vec{R}}{R^3}dS\right) \quad (1)$$

Where, R is the distance from the magnetic field source point to the coordinate point, dV is the permanent magnet volume component, and dS is the permanent magnet boundary closed curve integral element, ρ_m is the magnetic charge density.

The Gaussian quadrature formula is applied to the formula (1), the interpolation method and the polynomial fitting are adopted,A space magnetic field expression of that approximate partial fit curve is obtained, and if only the z-axis direction is consider, the expression is as follows:

$$\mathrm{B}(z) = 410.26z^2 - 50.38\mathrm{z} + 0.58 \quad (2)$$

According to Faraday's law of electromagnetic induction, the induced current is:

$$\int_0^{T_d} I\,\mathrm{dt} = \frac{nS}{R}\int_0^{T_d}\frac{dB}{dz}\cdot\frac{dz}{dt} = \frac{nS}{R}(A-B) \quad (3)$$

According to the Newton Leibniz formula, the solution is:

$$A = \int_0^{T_d} 820.52z(t)\cdot z'(t) = 0.825\times10^{-2} \quad (4)$$

$$B = \int_0^{T_d} 820.52z(t)\cdot z'(t) = 1.385\times10^{-2} \quad (5)$$

Substituting the formulas (4) and (5) into the formula (3) to obtain the induced current,$I \approx 0.0232\mathrm{A}$

Calculate that electric energy generated in a vibration cycle accord to the fact that the thermal effect is equivalent to the electric energy:

$$W = I^2RT_d = (0.0232)^2\times4747\times0.89 \approx 2.274J \quad (6)$$

According to the temperature gun on the market, in the case of two No.7 batteries, it can thermometry 500 times.After calculation, it is necessary to consume electric energy to measure

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the temperature once. Under the above conditions, shake 9-10 times to measure the temperature once.19.4*J*

7.3. Infrared thermometry

At the time of actual measurement,The effective radiation received by the infrared temperature measurement gun includes three parts: the target's own radiation, the environmental reflection radiation and the atmospheric radiation.The formula of the infrared thermometry gun is:

$$Q = \mathrm{T}[\sigma\varepsilon_S(T_s^n - T_r^n) + \sigma\rho_S(T_u^n - T_r^n)] + \sigma\varepsilon_\alpha T_a^n \tag{7}$$

In the formula, Q indicates the infrared radiation energy density received by the infrared temperature measuring gun; T_s^n、T_r^n、T_u^n、T_a^n respectively indicate the object to be measured, the temperature sensor and the surrounding environmentAnd the temperature of the atmosphere; ε_S、ε_α are the maximum emissivity of the measured object and the atmosphere, respectively.

From equation (7), the following temperature correlation formula of the object itself T_S can be derived:

$$\mathrm{T}_S = \sqrt[n]{\frac{Q}{T\sigma\varepsilon_S} - \frac{\varepsilon_u}{T\varepsilon_S}T_a^n - \frac{\rho_S}{\mathrm{T}_S}(T_u^n - T_r^n) + T_r^n} \tag{8}$$

It can be seen from the formula (8) that the ambient temperature has a greater impact on its own temperature. Next, the formula is compared with the actual measurement.Analyze the effect of ambient temperature.

As can be seen from fig. 11, when the thermometry in the room is 15 mm and 30 mm away from the neck,According to the comparison between the temperature calculated by formula (8) and the actual measurement, it is concluded that the error of thermometry is small when the distance is 15 mm from the neck.The average thermometry was 36.35 ℃, the measured body temperature was 36.4 ℃, and the error was 1.3%. Within the range of theoretical error.

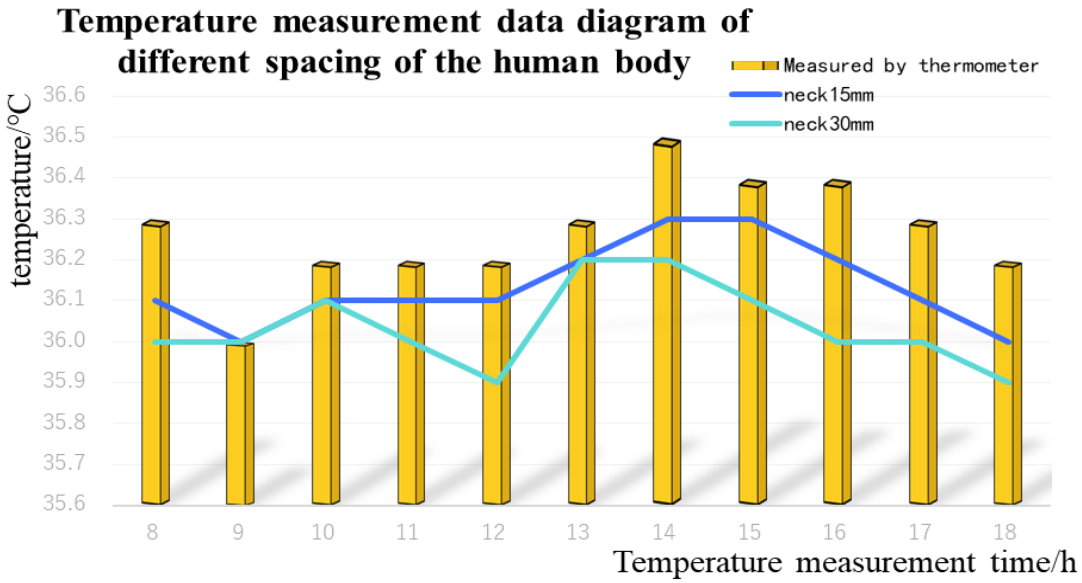

Fig. 12 Relation between human body temperature and test distance

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8. Innovation significance and application prospect

8.1. Infrared thermometry

(1) "Self-sufficiency" — permanent magnet cutting coil power generation

The device adopts the permanent magnet cutting coil to generate electricity as an energy supply means, and the technology avoids the dependence on disposable batteries,Thereby reducing the potential pollution of the waste battery to the environment and avoiding the harm of the leaky battery to human health.The self-powered design allows the temperature gun to be used without a power supply.

(2) "Portable and easy to use"-multi-scenario application

The temperature measuring gun is small in size, light in weight and convenient to carry and store.Ince pow generation is not dependent on an external power source, even in that event of pow interruption or a harsh environment,The electric energy can be generated only by simply shaking by a user, and the thermometry function can be realized quickly and accurately by using the infrared detection of the front end.

(3) "photographic memory"-integration of information storage and reading

The device can not only display data on the screen, but also store the historical temperature into a register through the singlechip,The function of memory is realized. When the historical temperature needs to be read, it can be directly transmitted through the USB interface of the computer.Based on these advantages, this product can better serve medical care and provide timely and accurate data.

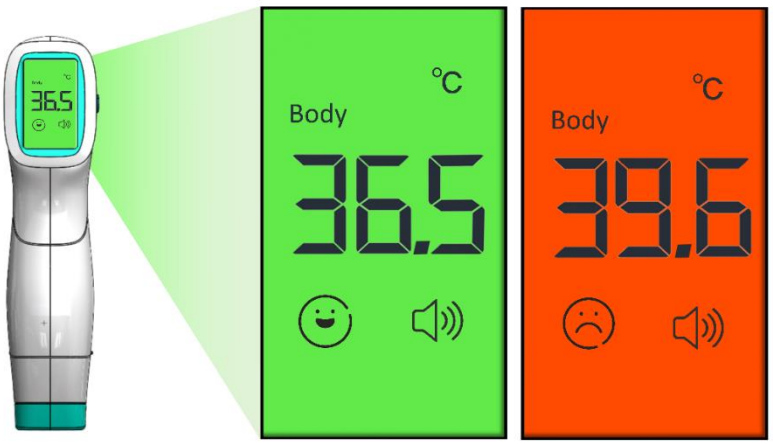

Figure 13 Screen Display Diagram

8.2. Infrared thermometry

(1) Application in medical field

In temperature measurement in public places, the self-generating temperature measuring gun can quickly and accurately measure the temperature of the human body without contacting the skin.Reduce the risk of cross infection. In terms of home care, a temperature gun can meet the needs of the whole family, and there is no need for standing batteries.

(2) Application in scientific research and education

In the process of educational demonstration, the principle of self-generating technology can be used as a visual teaching aid for electromagnetics in physics teaching;In the scientific research project of field investigation, the temperature data can be recorded continuously without replacing the battery.

(3) Other potential application fields

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In the outdoor field, outdoor users such as climbers can use self-generated temperature guns to monitor the temperature of themselves and their equipment.To ensure the safety of outdoor activities; in military operations, soldiers can use this technology to make covert temperature measurements;The design without power supply avoids the trouble of carrying batteries and further improves the waterproof performance.It provides a guarantee for its application in more fields.

Figure 14 Design Drawing of Magnetic Temperature Detection Poster

References

[1] KONG Fanguo, WU Guanlin.Theoretical study on electromagnetic highway speed bump power generation device [J].Mechanical Design and Manufacturing, 2014 (04): 76-78. DOI: 10.19356/J.cnki.1001-3997.2014.04.024.

[2] Yan Junyi. Design of bicycle power generation device based on cutting magnetic induction line [J].Journal of Inner Mongolia Normal University (Natural Science Chinese Edition), 2015, 44 (05): 617-619 + 624.

[3] SHAO Kai-bing, Jin Ai-ling, CHen Pei.A self-generating electronic pen for teaching and office [J].China New Communication, 2016,18 (05): 71-72.

[4] Du Xiaozhen. Research on Key Technology of Micro Piezoelectric Generator Driven by Ambient Vibration [D]. Dalian University of Technology, 2009.

[5] CHENG Guangming, pang Jianzhi, Tang Kehong, et al.Development of testing system for power generation capacity of piezoelectric ceramics [J].Journal of Jilin University (Engineering Science), 2007 (02): 367-371. DOI: 10. 13229/J. CN ki. Jdxbgxb 2007.02.024.

[6] Wang Jian, Guo Jifeng, Guo Shuai.Review of piezoelectric power generation technology [J].Piezoelectricity and Acousto-Optics, 2011,33 (03): 394-398.

[7] REN Jing-qiu, ZHONG Pan, ZHang Lin, et al.Study on temperature measurement compensation of human body infrared thermometer [J].Electronic Measurement Technology, 2021, 44 (16): 62-67.DOI:10.19651/j.cnki.emt.2106950.