# Research on the Mechanism of a Thermistor-type Electronic Thermostat

**Tiger Hu Sun [1,*], Junyu Ge[1], Kun Tan [2], Yongjiang Wu [3], Zhihang Jia [1], Yunquan Chen [1], Cheng Liu [1]**

[1] *Faculty of Civil Engineering and Mechanics, Jiangsu University, Zhenjiang, China*

[2] *School of Naval Architecture & Ocean Engineering, Jiangsu University of Science and Technology, Zhenjiang, China*

[3] *Jingjiang College, Jiangsu University, Zhenjiang, China*

**Abstract:** *This research provides a thermistor-type electronic thermostat, which includes a shell, a tail handle installed at the bottom of the shell, a gland installed at the top of the shell, a push rod and a spring arranged in the shell. A rubber tube is arranged at the top of the inside of the shell, one end of the push rod extends into the rubber tube through the gland, and extends into the top of the spring through the rubber tube. The bottom of the spring is connected with the tail handle, and the spring expansion can make the push rod move up and down. The parallel thermistor is arranged into the tail handle, which includes 6-10 thermistors, and it is connected in series with the spring, the power supply and the controller through a wire. In this research, the extension range of the push rod is increased by setting the spring in order to improve the working efficiency of the thermostat. Furthermore, the thermistors in this research improve the sensitivity of the thermostat, which can accurately and sensitively control the opening and closing of the cooling system in the engine cooling system.*

**Keywords:** *Thermostat, Thermistors, Parallel, Sensitivity, Cooling system, Spring expansion, Mechanism.*

## 1. INTRODUCTION

At present, the thermostat can be divided into ordinary wax-type thermostat, new electronic thermostat, pneumatic thermostat and so on [1–2]. Although these three types of thermostats are constantly improving, they still can not avoid their disadvantages in application. The following mainly summarizes the existing problems [3–5].

Paraffin in ordinary wax-type thermostat is solid at normal temperature. When the engine water temperature is high, the temperature sensing paraffin expands and compresses the rubber tube, and then pushes the push rod to move. Driven by the push rod, the valve gradually opens, which opens the large cycle, and makes the cooling water in the large cycle circuit of the engine flow to the radiator and the engine begins to dissipate heat [6–8]. When the temperature decreases, the push rod begins to fall back under the action of the spring, the valve closes, which also closes the large cycle, and the cooling speed decreases [9]. But the ordinary wax-type thermostat has the problems of "hysteresis" and "response delay", so it can not control the opening and closing of thermostat accurately and quickly [10-12]. The new electronic thermostat is to install a resistance heater on the temperature control element of the ordinary wax-type thermostat, and the heating amount is adjusted by controlling voltage and current value according to the controller to achieve the paraffin melting at the same time [13-14]. However, the principle of controlling the movement of push rod has not been changed. It always uses the hydraulic principle to push the push rod by the extrusion pressure of liquid paraffin expansion, which still can not overcome the problem of the time required for paraffin dissolution and the thrust generated by paraffin dissolution [15]. Pneumatic thermostat is composed of valve driving mechanism, valve mechanism, bracket, etc. The air pressure produced by liquid vaporization is used to control the opening and closing of the valve. However, the control accuracy and reliability of the thermostat are low [16].

In view of the shortcomings in the existing technology, the research provides a thermistor-type electronic thermostat, which can accurately and sensitively sense the temperature change, thus quickly control the movement of the push rod and realize the goal of temperature saving.

## 2. ADVANTAGES AND SIGNIFICANCE OF THE RESEARCH

### 2.1. Major improvements

（1）The inner wall of the tail handle is provided with an insulating layer, a sleeve is arranged inside the

tail handle, the parallel thermistor comprises eight thermistors, and the eight thermistors are arranged between the sleeve and the inner wall of the insulating layer in turn.

（2）The selected spring is a memory spring.

（3）The tail handle is connected with the bottom of the shell by thread.

（4）The wire is connected with the controller through the bottom wire hole of the tail handle, and an insulating filler is provided inside the wire hole.

（5）A sealing washer is arranged at the center of the connecting surface of the gland and the rubber tube, and the sealing washer is sleeved on the push rod for transitional matching with the push rod.

### 2.2. Beneficial effect of the research

（1）The thermistor has a fast response and improves the sensitivity of the thermostat. It can be used in the engine cooling system to accurately and sensitively control the opening and closing of the cooling system.

（2）By setting the spring, the extension range of the push rod is increased, which can improve the working efficiency of the thermostat.

（3）The controller controls the current flowing through the thermistor to control the elongation of the spring and the movement of the push rod.

## 3. COMPOSITION AND INTRODUCTION OF THE EQUIPMENT

In this part, the structure of each part of the thermistor-type electronic thermostat is introduced in detail. It mainly includes the following four figures.

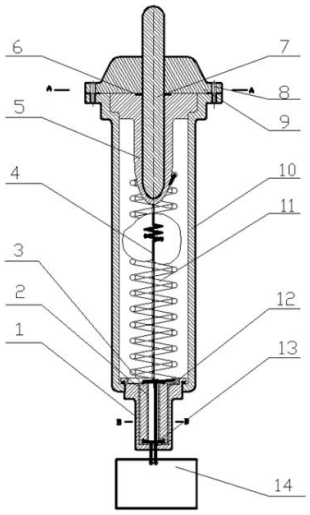


**Fig.1.** *Structure diagram of a thermistor-type electronic thermostat*

As shown in Fig.1, the thermistor-type electronic thermostat of the invention includes a shell 10, a tail handle 1 installed at the bottom of the shell 10, a gland 9 installed at the top of the shell 10, a push rod 7 and a spring 11 arranged in the shell 10. The spring 11 in the embodiment is a memory spring.

As shown in Fig.2, the shell 10 and the gland 9 are connected by four screws 8.

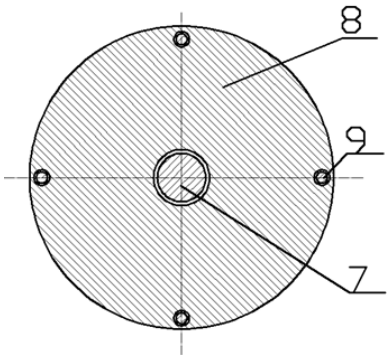


**Fig.2.** *Section view in A-A direction*

As shown in Fig.1, the top end of inside of the shell 10 is provided with a rubber tube 5, one end of the push rod 7 extends into the rubber tube 5 through the gland 9, and extends into the top end of the inside of the spring 11 through the rubber tube 5, the bottom of the spring 11 is connected with the tail handle 11, and the extension of the spring 11 can make the push rod 7 move up and down. A sealing washer 6 is arranged at the center of the connecting surface of the gland 9 and the rubber tube 5. The sealing washer 6 is sleeved on the push rod 7 and is transitional matched with the push rod 7 to prevent the rubber tube 5 from softening or overflowing into the gap between the push rod 7 and the gland 9. The tail handle 1 is connected with the bottom of the shell 10 through a thread, and a sealing ring is arranged at the joint to play a sealing role.

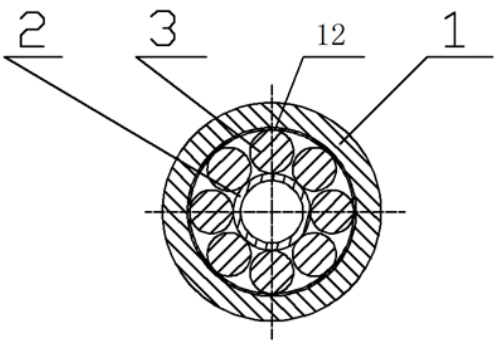


**Fig.3.** *Section view in B-B direction*

As shown in Fig.1 and Fig.3, the inner wall of the tail handle 1 is provided with an insulating layer 12, and the tail handle 1 is provided with a sleeve 3 and a parallel thermistor. In this embodiment, the parallel thermistor comprises eight thermistors 3, and the eight thermistors 3 are arranged between the sleeve 3 and the inner wall of the insulating layer 12 in turn.

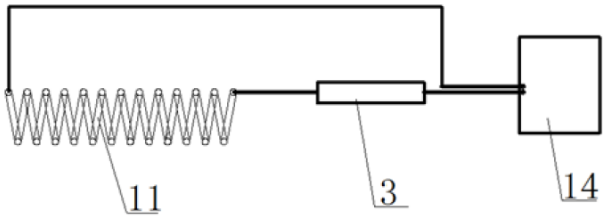


**Fig.4.** *Wiring connection diagram of a thermistor type electronic thermostat*

As shown in Fig.4, the parallel thermistor and the spring 11 are connected in series through a wire, the wire is connected with the controller through the bottom wire hole of the tail handle 1, and the wire hole is provided with an insulating filler 13.

## 4. WORKING MECHANISM OF THE EQUIPMENT

The equipment of this research is applied to the engine cooling system, and the controller 14 is used to sense the working state of the engine. When the engine temperature is too high, the controller 14 sends a command to the power supply, and the thermostat works at this time. The thermistor 3 in the tail handle 1 of the equipment senses the increase of temperature and then the resistance decreases, According to Ohm's law, the current in the conductor 4 and the memory spring increases, and the memory spring heats up, which can push the rubber tube 5 to move, and the rubber tube 5 drives the push rod 7 to control the valve of the cooling system to open the large cycle of the cooling system, so as to achieve the cooling effect. When the water temperature decreases, the resistance of thermistor 3 in the tail handle 1 increases, at this time, the current through the wire 4 and the memory spring decreases, the memory spring shrinks, and the rubber tube 5 drives the push rod 7 to rebound back, so as to close the valve of the system and close the large cycle of the system.

## 5. CONCLUSIONS

The thermistor-type electronic thermostat described in this paper can accurately and sensitively sense the temperature change to quickly control the movement of the push rod and realize the goal of temperature saving. Compared with the ordinary wax type thermostat, the new type electronic thermostat and the pneumatic thermostat, it has higher working efficiency and precision. The thermistor electronic thermostat senses the working state of the engine through the controller, and then it sends the command to the power supply, and the thermostat starts to work. When the temperature increases, the resistance of the thermistor decreases, and the current in the wire and the memory spring increases, through the spring, the movement of the rubber tube and the push rod is affected, and the valve of the cooling system is controlled to achieve the cooling effect. This process relies on the rapid response of thermistor, which makes up for the problem of "hysteresis" and "response delay" in thermostat, and has great advantages compared with the traditional thermostat.

**Acknowledgement**

This work was financially supported by The National Natural Science Foundation of China (Grant No. 11702116), The National Natural Science Foundation of Jiangsu in China (Grant No. BK20160484), and the Foundation of Jiangsu University (14JDG162).

## REFERENCES

[1] P. Patra, B. Bhattacharya. Zeroth Law investigation on the logarithmic thermostat. Scientific Reports, 2018, Vol.8, Article Number:11670.

[2] M. Adachi, P. Yu, et al. Magnetic excitation of a granular gas as a bulk thermostat. Npj Microgravity, 2019, Vol.5, Article Number:19.

[3] T. Soddemann, B. Dunweg, et al. Dissipative particle dynamics: A useful thermostat for equilibrium and nonequilibrium molecular dynamics simulations. Physical Review E, 2003(4), Vol.68, Article Number:046702.

[4] D. Munoz, E. Montero, et al. Difference temperature-to-time electronic interface based on a thermistor-to-generalized impedance converter. Measurement, 2010(10), Vol.43:1668-1675.

[5] P. Guadagnini, V. Barlette. Um termômetro eletrônico de leitura direta com termistor A direct reading electronic thermometer with thermistor. Revista Brasileira, 2005(3), Vol.27:369-375.

[6] Z. Long, D. Jiankai, et al. A novel defrosting method using heat energy dissipated by the compressor of

an air source heat pump. Applied Energy, 2014, Vol.133:101-111.

[7] F. di Liberto, R. Pastore, et al. Dissipated energy and entropy production for an unconventional heat engine: the stepwise 'circular cycle'. Philosophical Magazine, 2011(13-15), Vol.91:1864-1876.

[8] T. Hughes-Riley, P. Lugoda, et al. A Study of Thermistor Performance within a Textile Structure. Sensors, 2017(8), Vol.17, Article Number:1804.

[9] A. Samoletov, C. Dettmann, et al. Thermostats for "Slow" configurational modes. Journal of Statistical Physics, 2007(6), Vol.128:1321-1336.

[10] E. Strelcov, Y. Lilach, et al. Gas Sensor Based on Metal-Insulator Transition in VO2 Nanowire Thermistor. Nano Letters, 2009(6), Vol.9:2322-2326.

[11] X. Wang, Z. Xie, et al. Gas sensors, thermistor and photodetector based on ZnS nanowires. Journal of Materials Chemistry, 2012(14), Vol.22:6845-6850.

[12] A. Feltz, W. Polzl. Spinel forming ceramics of the system FexNiyMn3-x-yO4 for high temperature NTC thermistor applications. Journal of the European Ceramic Society, 2000(14-15), Vol.20:2353-2366.

[13] P. Umadevi, C. Nagendra. Preparation and characterisation of transition metal oxide micro-thermistors and their application to immersed thermistor bolometer infrared detectors. Sensors and Actuators A-physical, 2002(2-3), Vol.96:114-124.

[14] R. Schmidt, A. Brinkman. Studies of the temperature and frequency dependent impedance of an electroceramic functional oxide NTC thermistor. Advanced Functional Material, 2007(16), Vol.17:3170-3174.

[15] J. Cao, Z. Wang, et al. Vertical SnSe nanorod arrays: from controlled synthesis and growth mechanism to thermistor and photoresistor. Nanotechnology, 2014(10), Vol.25, Article Number:105705.

[16] Q. Wang, J. Zhang, et al. Study on the Thermal Properties of Paraffin/Expansion Perlite Composite Phase Change Mortar. Sustainable Development of Urban Environment and Building Material, 2012, Vol.374-377:1274-1277.