

# Design of Temperature Monitoring System for Raw Milk Transportation Based on TRIZ Theory

1st Wenli Zhang, 2nd Tingting Cheng, 3rd Huamin Chen, 4th Xiang Guo, 5th Guohua Gao

The college of information and communications engineering, Faculty of Information Technology, Beijing University of Technology, Beijing, China

zhangwenli@bjut.edu.cn, 307812512@qq.com

**Abstract.** For the safety of dairy products, the quality of milk (raw milk) is particularly important. Because temperature influences the number of bacteria in raw milk, the suitable temperature can make the storage time of raw milk longer. Therefore, the realization of raw milk temperature monitoring system is particularly important. The two key problems in the hardware design of the system are hardware layout and power supply design. These two problems are solved by applying TRIZ (theory of inventive problem solving) theory. TRIZ theory is through the interaction analysis between components, using physical contradictions, technical contradictions, and combined with the principle of invention, finally find the solution to the problem.

## 1. Introduction

In recent years, food safety incidents have occurred frequently<sup>[1]</sup>. For dairy products, we should control the quality of milk sources (raw milk). The temperature has a great influence on raw milk, and the suitable temperature can make the storage time of raw milk longer. Therefore, the design of raw milk temperature monitoring system is important to ensure the safety of dairy products. The temperature monitoring system designed in this paper is aimed at the raw milk transport process. This design uses TRIZ theory to complete the hardware layout and power supply design issues. The TRIZ theory method is a theoretical system formed by researchers led by G.S.Altshuller by analyzing a large number of patents and synthesizing the principles and rules of multiple subject areas. TRIZ<sup>[2]</sup> is a theoretical system of technological innovation, originally used for technology systems, and has made positive progress in many fields of research. The task of innovation design is to solve all kinds of contradictions in the process of improving design and focus on the focal point of "contradiction".

In TRIZ theory, solving physical contradictions and technical contradictions is considered to be the key to innovative design. Physical contradiction means that in order to achieve some function, a subsystem or element should have one characteristic, but at the same time, it has the opposite characteristic. The core of physical contradiction refers to the contradictory and contradictory requirements for an object or a subsystem in a system. The technical contradiction refers to the two effects of a function that produces both useful and harmful effects at the same time. It always involves 2 basic parameters: when one parameter is improved, the other parameter will deteriorate<sup>[3-5]</sup>.

In this study, we first analyze the system components based on the specific problems. And then the interaction of all components of the system is analyzed. Then the component function model is established based on the interaction between components. Finally, the inventive principles are derived from physical contradictions and technical contradictions.



The paper structure is as follows: The first chapter is introduction; the second chapter introduces the analysis and solution of hardware layout problem of temperature monitoring system based on TRIZ theory; the third chapter discusses the analysis and solution of power design problem of temperature monitoring system based on TRIZ theory; the fourth chapter is conclusion.

**2. Analysis and solution of hardware layout problem of temperature monitoring system based on TRIZ theory**

If the temperature monitoring device as a whole is placed in the tank sandwich of milk tanker, then the communication signal will be weakened. In view of this problem, the TRIZ theory is discussed.

*2.1. Component analysis*

The temperature monitoring system is analyzed by TRIZ theory. The system components are master control, temperature sensor, line, GPRS communication module, Power supply, tank body, radio wave. Moreover, the super system components of the system are raw milk, water vapor in the interlayer of a tank. The system components and super system components are shown in Table 1.

Table 1. Temperature monitoring system components.

Engineering system	The main function	Components	Super system components
Temperature monitoring device	Monitoring temperature information	Master control	Raw milk
		Temperature Sensor	
		GPRS communication module	
		Power supply	Water vapor in the interlayer of a tank
		Tank body	
		Radio waves	

*2.2. Component interaction analysis*

The interaction among components is analyzed for all components of the system. The interaction between components is shown in Table 2.

Table 2. The interaction of the components of the temperature monitoring system.

	Master control	Temperature Sensor	GPRS communication module	Power supply	Raw milk	Tank body	Water vapor in the interlayer of a tank	Radio waves
Master control		+	+	+	-	+	+	-
Temperature Sensor	+		-	-	-	+	+	-
GPRS communication module	+	-		-	-	+	+	+
Power supply	+	-	-		-	-	+	-
Raw milk	-	-	-	-		+	-	-
Tank body	+	+	+	-	+		+	+
Water vapor in the interlayer of a tank	+	+	+	+	-	+		-
Radio waves	-	-	+	-	-	+	-	

*2.3. System component function model analysis*

After the interaction analysis of the system, it can be analyzed that the stainless steel tank will weaken the radio wave signals emitted by the GPRS communication module. The water vapor in the interlayer of the tank will corrode the Master control, the power supply and GPRS communication module. The

functional model of the temperature monitoring system component is established by reference to the literature<sup>[6]</sup>. The functional model is shown in Figure 1.

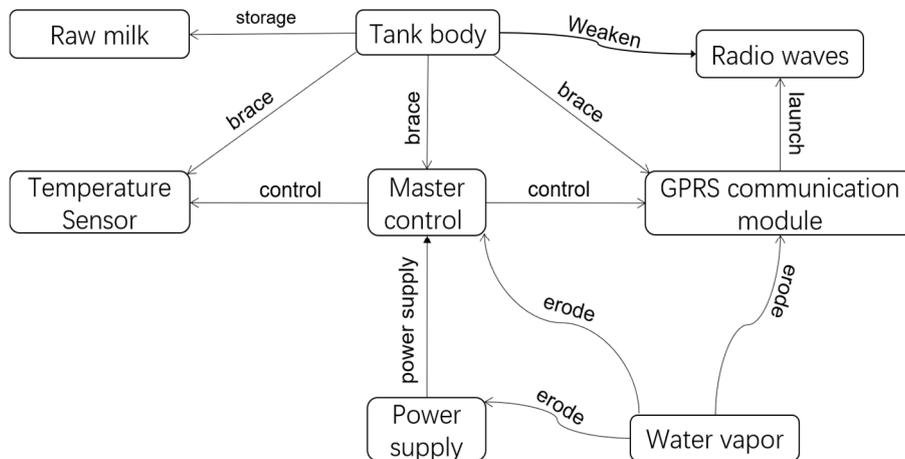


Figure 1. Component function model of temperature monitoring system.

#### 2.4. Physical contradiction analysis and problem solving

The physical contradiction that this design needs to study is where the hardware of the temperature monitoring system should be placed. The corresponding physical contradiction Description: if the temperature monitoring device is placed outside the milk tank car, the wireless communication signal can be sent normally; but the temperature information cannot be detected normally. In the process of solving physical contradictions, we first separate them according to the corresponding conditions, so that the problem can be solved by the spatial separation method. By searching for the corresponding principle of space separation and according to the actual conditions of the temperature monitoring system, the innovation principle 3: the local mass principle, is selected and the system is designed with this principle.

the local mass principle that different parts of the object have different functions. Let all parts of the object be in the best state of completing their respective actions. This results in the temperature sensor are placed in the tank interlayer for detecting the temperature information of the milk, and other device parts are placed outside the tank. So that all parts are in the best state of completing their respective actions. The position diagram of the temperature monitoring system is shown in Figure 2.

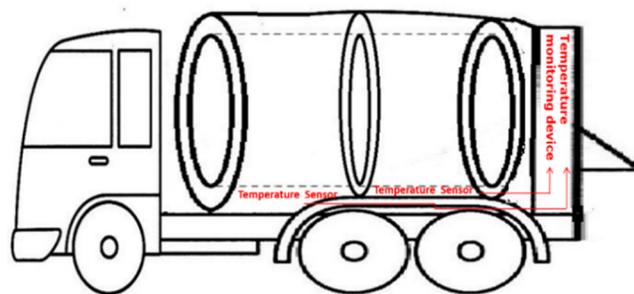


Figure 2. Component function model of temperature monitoring system.

### 3. Analysis and solution of power design problem of temperature monitoring system based on TRIZ theory

The temperature monitoring device studied in this paper is used to monitor the temperature change during the transportation of raw milk. Therefore, the first choice of the power supply of the temperature monitoring system is to connect the temperature detection device directly with the cigarette lighter of the milk tanker and supply the temperature detection device through the battery of

the milk tanker. However, the scheme will cause the temperature monitoring device of milk tanker to be out of order after being extinguished. In view of this problem, the TRIZ theory is discussed.

*3.1. Component analysis*

the power module of the temperature monitoring system is analyzed by TRIZ theory. The system components are battery, car cigarette lighter, line. Moreover, the super system components of the system are temperature monitoring device (including: temperature sensor, master control, GPRS communication module), milk tanker. The system components and super system components are shown in Table 3.

Table 3. The power supply of the temperature monitoring system components.

Engineering system	The main function	Components	Super system components
The power module of the temperature monitoring device	Supply the power for the whole temperature monitoring device	Battery	Temperature monitoring device (including: Temperature sensor, Master control, GPRS communication module)
		Car cigarette lighter	Milk tanker
		Line	

*3.2. Component interaction analysis*

The interaction among components is analyzed for all components of the system. The interaction between components is shown in Table 4.

Table 4. The interaction of the components of the power supply of the temperature monitoring system.

	Battery	Car cigarette lighter	Line	Temperature monitoring device	Milk tanker
Battery		+	-	-	+
Car cigarette lighter	+		+	-	+
Line	-	+		+	-
Temperature monitoring device	-	-	+		+
Milk tanker	+	+	-	+	

*3.3. System component function model analysis*

After the interaction analysis of the system, it can be analyzed that the power supply to the temperature monitoring device in the car cigarette lighter is insufficient. When the car is flameout, the temperature monitoring device will not continue to work. The functional model of the power supply of the temperature monitoring system component is established by reference to the literature<sup>[6]</sup>. The functional model is shown in Figure 3.

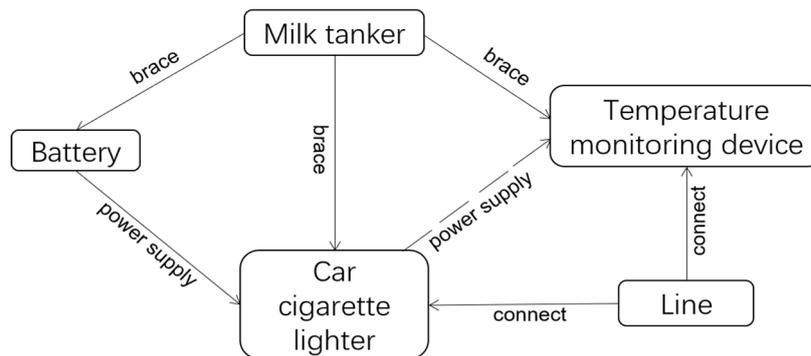


Figure 3. Component function model of the power supply of temperature monitoring system.

### 3.4. Technical contradiction analysis and problem solving

The technical contradiction that this design needs to study is how to design the power module of the temperature monitoring system. The main purpose is to eliminate the influence of the power supply status of the temperature monitoring device is affected by the state of milk tank car (start / flameout). The corresponding technical contradiction Description: if the power module of the temperature monitoring device is directly connected to the battery of a milk tanker, the temperature monitoring device can be prevented from being affected by the state (start / extinguishing) of the milk tanker, but the battery will be discharged all the time. When the battery is exhausted, the vehicle will not start properly. First, to find the improved parameters and the deteriorated parameters according to the specific technical contradictions. Then, the corresponding principles are found according to the two parameters. Finally, the problem is solved by the principle of invention. According to the technical contradiction, the improvement parameters are obtained: the reliability of the system; the deterioration parameter: the energy loss. Therefore, the invention principles for solving this problem are 10: segmentation principle; 11: preset precaution principle; and 35: performance conversion principle.

The preset precaution principle is used to solve the design problem of power supply. The preset precaution principle that the system should be compensated accordingly to improve its reliability by using prepared contingency measures. According to the preset precaution principle, we can install a power supply independent of the milk tanker to power the temperature monitoring device and add a charging function to the power device so that the temperature monitoring device can work all the time.

## 4. Conclusions

This article has solved two problems in the design of temperature monitoring system for raw milk transportation through TRIZ theory. But at the present stage, the application of TRIZ theory is not very common, so long as it is used in large enterprises. The main reasons are three points: first, the TRIZ theory is more abstract and the structure is complex; then the bottleneck factor of the effect of the TRIZ application<sup>[7]</sup>; the last state department has little application and promotion to the application of TRIZ, and the degree of attention is not high, which leads to the lack of application.

## Acknowledgments

The research has been supported by the special project of the Innovation Method of the Ministry of Science and Technology (No. 2016IM020400). The project is called "Research and Demonstration of Innovative Methods for Quality Control of the Whole Chain of Dairy Products" (2016/10-2019/10).

## References

- [1] Xu Qian, Xie Jing. Temperature monitoring in food safety and food low temperature circulation [J]. Journal of Shanghai Fisheries University, 2007, (2): 180-184. DOI:10.3969/j.issn.1004-7271.2007.02.016.
- [2] Zhao Min, Shi Xiaoling, Duan Haibo. TRIZ entry and practice[M]. Beijing: Science Press, 2009:

- 13-15.
- [3] Chen Minhui, Jiang Yanping, Lv Jianqiu. Research status, existing problems and Countermeasures of TRIZ research at home and abroad. [J]. science and technology management research, 2015, 35 (1): 24-27.
  - [4] Gao Changqing, Huang Kezheng, Zhang Yong. Comparison and application of problem solving tools in TRIZ theory [J]. mechanical design and research, 2006, 22 (1): 13-15.
  - [5] Zhang Jianyi, Guo Yanling, Yang Shucui, et al. Product innovation design based on TRIZ theory [J]. mechanical design, 2009, 26 (2): 35-38.
  - [6] Gao Guohua, Ma Shuai. Optimization of potted flower transplanting gripper based on discrete element analysis and field analysis [J]. Acta agri engineering, 2017, 33 (6): 35-42.
  - [7] Yang Yawen, Guo Xinbao. TRIZ analysis of constraints in management innovation application[J]. Innovative technology, 2013(4):10-11