Research on Enhancing the Efficiency of Fire Extinguishing Method with Water Based on TRIZ

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Abstract: In the face of raging fire, the affected people anxious. How to effectively control the fire? How to quickly eliminate the fire? These problems are one of the most important issues that the fire brigade will continue to solve. Water is the most commonly used the most effective fire extinguishing agent. How to use the same amount of water to destroy a larger area of fire? How to put out the fire at the first time? How to better protect people's lives and property? This paper revolves around these issues.

The fundamental problem of this paper is that the efficiency of fire engines is not high, so, that is no effective control of fire. Then, according to the three bad phenomena of the firefighting scene (insufficient, freezing, discontinued), we use causal analysis to find the three breakthrough points of the problem. We use the contradictory analysis and Substance - field analysis to solve; get the final effective solution. That is, on the basis of the existing fire engines, we will increase the heating equipment to heat the water to high temperature which is more conducive to the fire extinguishing and quickly generate large amount of water vapor in the fire site. And, after practice and market test, this study has achieved great social and economic benefits.

The innovation of this paper is that the TRIZ theory is applied to the design of water heating fire engines. Through the analysis and combing of TRIZ theory, it has successfully promoted the fire-extinguishing efficiency of water fire-fighting fire engines, and has succeeded in saving water resources and protecting the environment.

Key words: TRIZ; Causality Analysis; Technique contradiction; Substance - Field analysis; Extinguishing efficiency

Fire is caused by people with fire accidentally, illegal operation, arson, smoking and other factors. According to the Ministry of Public Security Fire Department published the first half of 2016 fire statistics, 2016 January to June, the country reported a total of

172,000 fires, 911 deaths, 756 injured, that is the direct property losses is 1.92 billion. More quickly and efficiently put out the fire, will better protect the people's personal and property safety. How to achieve "less water, good effect", is an important way to effectively enhance the combat effectiveness of the fire brigade.

The paper is composed of five parts, the first is the description of the research background and problem; the second is the causal analysis of the problem; the third is the use of contradiction analysis, object-field analysis method to try to solve; four is to establish practical solutions; Fifth, summarize the research results and expected benefits.

1 Introduction

The formation of fire must have three elements, which are the fuel, oxygen and heat. To make the combustion process continue, the three are indispensable. Therefore, extinguishing the fire or controlling the fire must eliminate at least one of these three elements.

1.1 Commonly used firefighting methods

Depending on the nature of combustion, commonly used extinguishing methods include isolation, suffocation, cooling, and inhibition.

Isolation method is to allow flammable materials away from the flames; we can let the fire place or object with the surrounding fuel isolation.

Suffocation method is to prevent the flow of air into the combustion zone, so that the combustion products do not get enough oxygen.

Inhibition method is to let the fire extinguishing agent to participate in the combustion reaction, interrupt the combustion chain reaction, to achieve the purpose of extinguishing.

Cooling method refers to the extinguishing agent is sprayed onto the fire source and nearby combustibles. So that， when the temperature is lowered, and the combustion is stopped.

At present, firefighters use water and carbon dioxide to cool off the fire.

1.2 Analysis of the use of water to extinguish the fire

Water, as the most common extinguishing agent, is the most widely used in daily life. It is determined by its physical and chemical properties.

The first is to cool combustibles. When 1 kg of water vaporization to absorb 539.9

kcal of heat.

The second is to reduce the oxygen content in the air.

After encountering high temperature combustion, water produces water vapor, water vapor can prevent air from entering the combustion zone and dilute the oxygen content of the combustion zone, so that the gradual lack of combustion of oxygen and reduce the combustion intensity.

The third is dilute water-soluble combustible, flammable liquid. Water reduces the concentration of combustible or flammable liquids, reducing the intensity of combustion.

The fourth is emulsified flammable liquid. Water formed a layer of milky surface in the flammable liquid surface, It can reduce the flammable liquid evaporation and make it difficult to continue burning.

The fifth is the high pressure shock. High-pressure water can break up the combustion material, so that the combustion intensity significantly reduced or even flame directly.

Use water to extinguish the fire, the main role of water is the cooling effect [1].

However, the water is not a panacea, due to the particularity of chemical substances; some substances cannot use water after the firefighting, for example, with water combustion of the material; flammable liquids with a specific gravity less than that of water and insoluble in water; Flammable powdery solid or charged electrical equipment and chemical dangerous goods and so on.

1.3 Undesirable phenomena described

In addition to these special circumstances, the water is reliable and practical first choice of fire extinguishing agent, in the actual fire-fighting process. We use the normal temperature water and ground water. The following problems occur during the process of firefighting and rescue.

First, the fire is still, the water is gone; in the fire rescue scene, need a lot of water to ensure that firefighting needs, after the fire, the first time there is no effective control, or a larger fire situation, the fire truck to carry the water cannot meet the needs of fighting fires.

Second, the fire is still, the water is frozen; in the winter cold season, fire hose in the suspended water supply time is easy to freeze, affecting the needs of water supply again.

Third, the fire is still, the fire truck is away; when the fire engine comes with the reserve water runs out, you need to get the water at source point of water, time delay in the rescue of the actual delay in fire control.

2 Causal analysis of the problem

Combined with TRIZ theory, the existing technical system is the ordinary water tank fire engines; its function is to spray ordinary fire extinguishing agent (water). The main components of the tank-fire truck include: car chassis, cab, compartment, water pump and piping, transmission system and operating mechanism. Its working principle is, the power of the engine is used for the fire pump operation by means of a transmission; and the water in the carriage is sprayed through fire pumps, firecrackers and fire extinguishers.

2.1 Problem generation and restrictions

In order to ensure rapid fire extinguishing, it is necessary to improve the fire extinguishing efficiency of water.

If the fire did not be destroyed but the water shortage, the fire will spread larger, difficult to control, resulting in greater losses; In order to ensure the normal use of suspended water supply in winter cold season, it is necessary to delay the freezing speed of water zone.

2.2 Analysis of the proposed solutions

Existing solutions are mainly the following two:

First, increase the horsepower of fire engines, increase fire truck tank water tonnage, so that a single fire truck water carrying capacity to meet the fire needs of water. This program is difficult to achieve, and there are obvious flaws.

The disadvantage is that the fire truck water cannot be increased indefinitely, there are certain limitations; the same time, increased water in the fire truck, will inevitably affect the vehicle speeds, and the greater the tonnage, driving more unsafe, delay valuable firefighting time.

In addition, large-scale vehicles in rural roads or urban roads in the narrow case, cannot be successfully passed, cannot implement firefighting and rescue.

The second initial plan is to increase the insulation layer to slow down the freezing speed of the fire hose.

But there are some defects; the water zone to increase the insulation layer is not conducive to on-site operation.

2.3 Define the final ideal solution

The proposed solution did not improve the fire extinguishing efficiency of water well. Therefore, the requirement of the system is not only to overcome the previous defects, the most important thing is to improve the effectiveness of water fire. In other words, the new system is to improve the effectiveness of water fire at the same time, to ensure adequate fire extinguishing agent (water) and water with no ice.

In other words, the ideal final result (IFR) is the tank-fire truck arrived at the scene of the moment (quickly and effectively) the use of extinguishing agent - water extinguish the fire.

2.4 Causal analysis

Through the analysis of water tank fire extinguishing efficiency is not high, as shown in Figure 2.1, we found opportunities for technological improvements.

First, improve the efficiency of water fire, the second is to increase the fire truck water capacity, the third is to increase the insulation device.

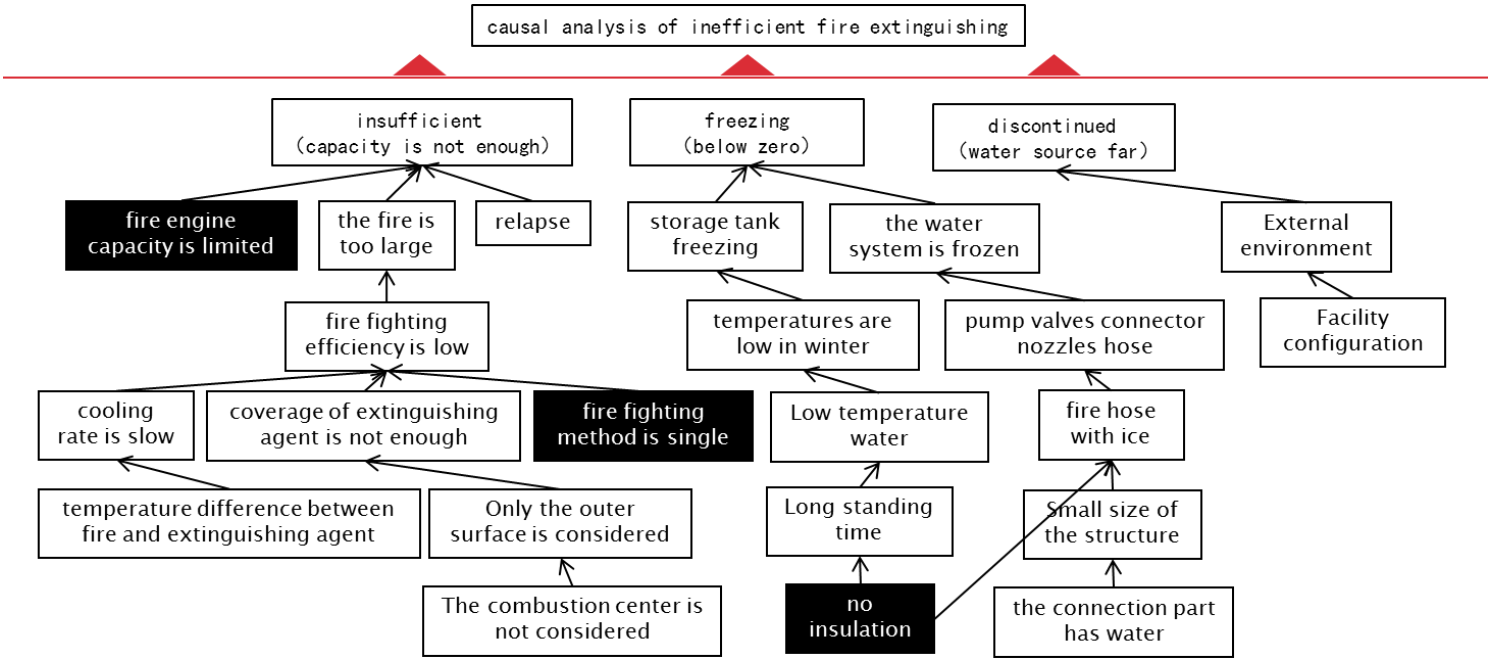

Figure 2.2 causal analysis of the fire efficiency is not high

3 Using technical contradiction and material - field model to solve

3.1 Limited capacity for fire engines

Fire engine capacity is limited, resulting in insufficient fire extinguishing agent. The current solution is to increase the water carrying capacity of fire engines, to avoid off supply. The disadvantage of the solution is that the vehicle speed decreases, delaying the timing of firefighting; the more unsafe driving; Large-scale vehicles in rural roads or urban roads in the narrow case, cannot be successfully passed, cannot implement firefighting and rescue.

According to the analysis, two pairs of technical contradictions were identified, namely, improved reliability (27), deteriorated speed (9); improved reliability (27) and deteriorated usability and versatility (35).

By finding the contradiction matrix, the principle of innovation is obtained. According to the principle of using intermediaries, we can use a substance for cold water heating and insulation; TRIZ emphasizes the use of cheap and free resources, so we can use the solar heating method; Sometimes, the sun is not sufficient in winter, resulting that, water cannot be heated the water in tank by solar; Through the precautionary principle and weight compensation principle, we can pre-set a way of electric heating as a backup.

3.2 Increase the insulation device

Fire hose water within the ice, resulting in fire extinguishing agent off for. Frozen water in the fire hose result in the extinguishing agent stopped supply. The current solution is to increase the insulation layer in order to delay the freezing speed of the water belt, to avoid extinguishing agent off supply. The disadvantage of the solution is not conducive to on-site operation, delay firefighting. Define one pair of technical contradictions; improving reliability (27) and degrading the ease of operation (33). According to the principle of cheap alternatives, we get some concept plan, for example, we can use a one-time fire hose. That is, using new fire hose while each rescue, but there is no viable new material, suitable for market demand.

3.3 Water cooling method is single

Because the water cooling method is single, the fire extinguishing efficiency is low. We increased operational firefighting methods - water vapor asphyxiation. We use cheap self-resources, which are water vapor generated by water. Low-temperature water into

water vapor per unit time is less efficient. So, the water vapor content per unit area is insufficient.

The use of water vapor asphyxia method of extinguishing, it is necessary to increase the water temperature. High-temperature water generates large amounts of water vapor in the extinguishing process, thereby reducing oxygen content at the fire site. Through the oxygen asphyxiation method get the fire was extinguished rapid.

It is clear that the key to the problem is the relatively low efficiency of cold water conversion into water vapor per unit of time. Definition S2 is cold water, S1 is water vapor; F is temperature field. Construct the Substance-field model of the problem, as shown in Figure 3.1.

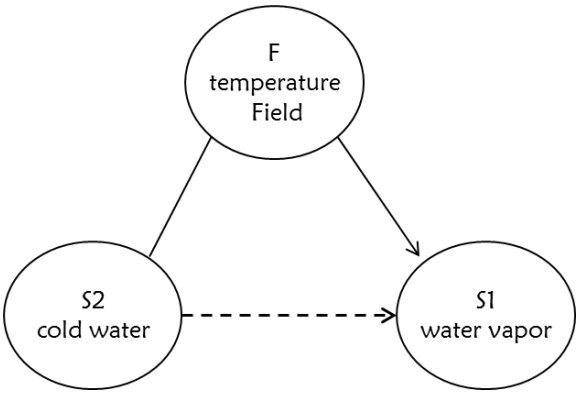

Figure 3.1 the constructed Substance field model

Using a standard solution, we establish a two-field model that introduces a thermal field that quickly turns water into water vapor. As shown in Figure 3.2.

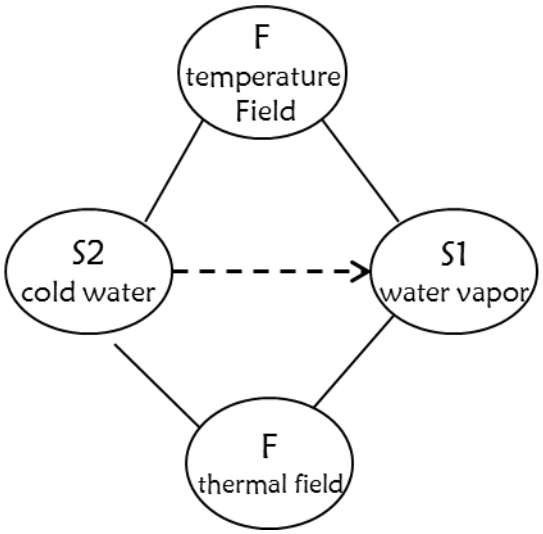

Figure 3.2 Two-field models

Further, the conceptual scheme is determined. The heating device preheats or insulates the water in the fire engine. After the fire, the hot water is quickly converted into water vapor. In a short period of time, hot water forms a large number of water

vapor; the vapor extinguishes the fire through the asphyxiation method.

3.4 Final program established

Based on the theory of TRIZ, on the basis of the existing fire engines, by improving the local structure and increasing the heating equipment to form high-temperature water, a large amount of steam can be generated rapidly in the fire site, reduce the oxygen content of the fire site, Rapid fire extinguishing (Figure 3.3).

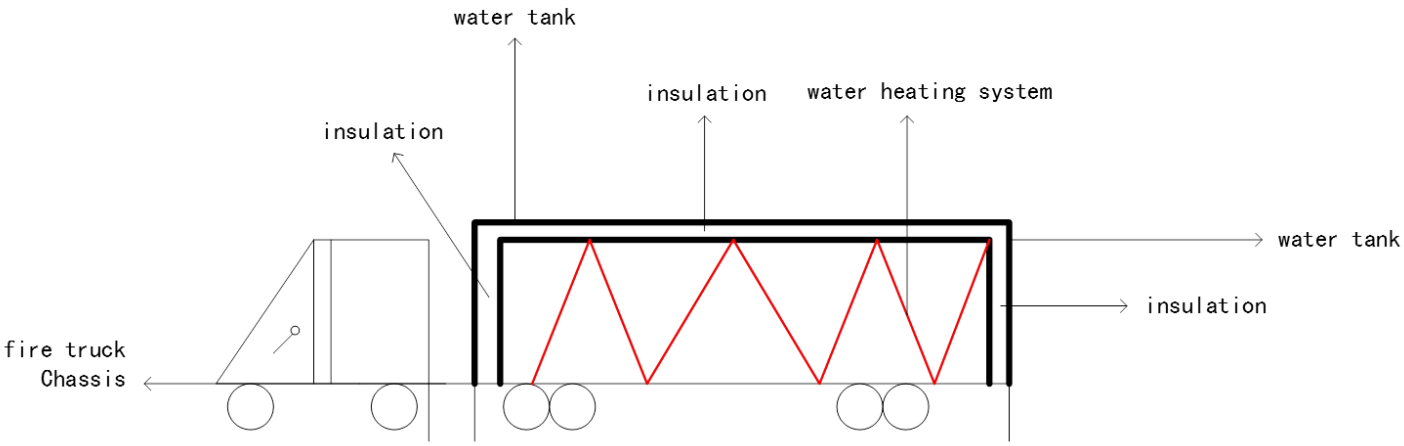

Figure 3.3 Schematic diagram of a water heating fire engine

The compartment is divided into fire water tanks and equipment area, the equipment area is equipped with fire-fighting equipment and heating system. The heating system includes electric heating system and solar heating system.

When the fire engine parked in the sun, the solar panels installed in the car will receive full sunlight, and they absorb the heat through the central control device to drive the circulating pump; in the circulation pipeline, the circulating pump will heat the heat medium and heat exchanger through the conduction of fire water tank to the water. The circulating pump transfers heat from the heat-conducting medium and the heat exchanger to the water in the fire-fighting water tank in turn.

If the intensity of sunlight is not enough, the water temperature cannot reach the set temperature, the temperature control panel can start the generating unit, to the heating plate power supply; the electric water heating system is used to heat the water inside the fire water tank. When the water temperature reaches the set temperature, the temperature control board stops the generating unit.

In this way, it can make full use of natural energy, but also maintain the tank water temperature; In the fire rescue, the driver started the fire pump, jet hot water, to achieve the fast fire-fighting purposes.

4 Summary and benefits

4.1 Summary

The fundamental problem of this paper is that the firefighting efficiency of water tank fire truck is not high; therefore, it is no effective control of fire.

Secondly, according to the three unhealthy phenomena of firefighting and rescue scene, using causal analysis method, we find the breakthrough point of three problems.

Then, the contradictory analysis and the object field analysis are used to solve these problems one by one.

Further, a final effective solution is obtained, that is, on the basis of the existing fire engines, the heating apparatus is added, and the water is heated to high temperature water more favorable to the extinguishing temperature.

High-temperature water quickly generates large amounts of water vapor at the scene of the fire, so the fire is rapidly quenched by water vapor asphyxiation (Figure 4.1).

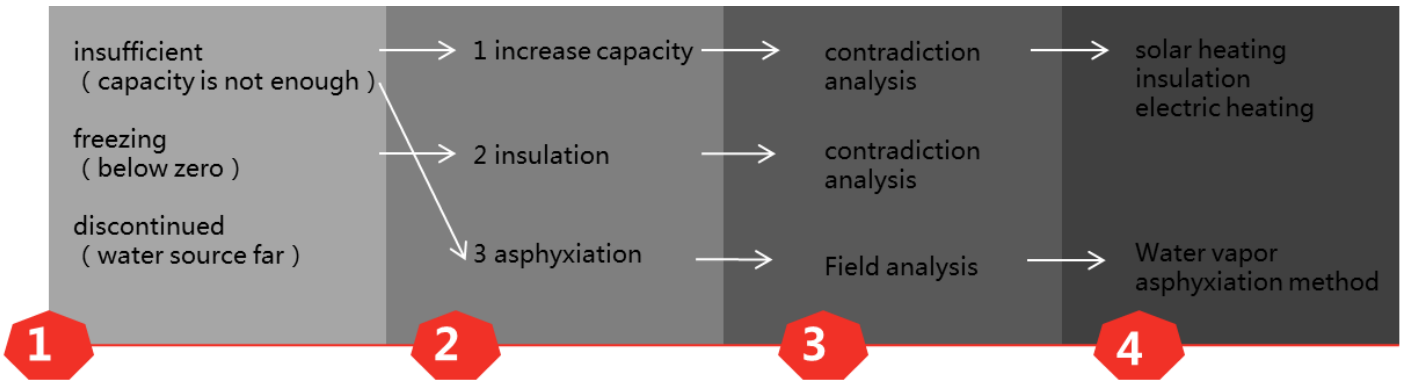

Figure 4.1 Structure of the paper

4.2 Achievements and benefits

This research has obtained the utility model patent, and the invention patent has accepted.

Direct benefit is very big. The fire will be extinguished at the first time, and it protects people's lives and property better. It enhance the fire fighting force effectively, five firefighters can complete the work of dozens of firefighters.

Social benefit is very big. Every second, 1 liter of hot water is equivalent to the role of 20 - 30 liters of cold water; it will save the rescue water. By using of solar heating, it will save the energy. Especially in winter and cold areas, it will protect the safety of firefighters, and reduce the harm to firefighters.

Economic benefit is very big. For ordinary fire engines, the increase cost is low, and the result of use is good. If this fire truck will sold at least 200 per year, it will achieve 50 million economic benefits.

References

1. http://www.cfm119.com/
2. Technology Innovation Theory (TRIZ) and application / edited by Zhao Xinjun. Beijing: Chemical Industry Press, 2004,4;
3. TRIZ Innovation Theory and Application Research / Zhang Shi Yun, Lin Yue editor. Beijing: Hualing Publishing House, 2010.5;
4. TRIZ Advanced and practical: The method of the invention Avenue to Jane / Zhao, Zhang Wu Cheng, a special crown. Beijing: Mechanical Industry Press, 2015.10;
5. Firefighters rescue and Survival，[United States] Richard Kohleme, Robert Hoff; Wu Peiying, Zhu Jiang translation, 2016.6;
6. Fire safety technology practice, Li Yongkang, Ma Guozhu, 2016.6.
7. TRIZ - Driving innovative technology/Isaac Bucman. China Science and Technology Press, 2016.11;
8. TRIZ Enhancement and Practical Applications/Zhao Min, Zhang Wucheng, Wang Guanshu. Machinery Industry Press, 2015.12;
9. TRIZ for Engineers：Enabling Inventive Problem Solving/Karen Garde; Luo Deming, Wang Lingyun, Jiang Jianting and other translations. National Defense Industry Press, 2015.9;
10. TRIZ -the golden key to open the door to innovation/Sun Yongwei, Sergei Ike Vanke. Science Press Limited Liability Company,2015.11.