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The Influence of TRIZ Theory on Mathematical Modeling

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Abstract: The TRIZ theory is the problem solving theory, and as an innovative theory and method, its core lies in providing a new way of thinking, new methods, and new results. Mathematical modeling itself requires this innovative method of overcoming inertia thinking. This article will take the study of tree planting plan and the discussion of the changes in gravitational force and period after lunar resources are transported to Earth as examples to explore the process of mathematical modeling guided by TRIZ theory.

Keyword: *Mathematical Modeling; Stc Operator; Triz Theory; New Ideas, New Methods, New Results*

I. A BRIEF INTRODUCTION TO TRIZ THEORY AND MATHEMATICAL MODELING

A. A brief introduction to TRIZ theory

The TRIZtheory originated from the former Soviet Union and was created by the great American inventor and engineer Archishuler and his colleagues. It was a theory that was finally summarized in 1946 after discussing and analyzing over 2.5 million high-level patent research results worldwide. The TRIZ theory has strong practicality and has been applied in various fields. It not only expands people's innovative thinking, but also seeks solutions to problems, providing innovative ideas and reference opinions for innovative problems in different fields.

B. A brief introduction to mathematical modeling

Mathematical modeling builds mathematical models based on real-life or the problems of competition, solving the established mathematical model, and then solving the problem based on the results obtained. It is a method of thinking about mathematics, a powerful mathematical tool for solving problems through mathematical language and methods. In 1992, the National College Student Mathematical Modeling Competition was established to select talents and increase people's understanding and emphasis on mathematical modeling.

II. THE ROLE OF TRIZ THEORY IN MATHEMATICAL MODELING

TRIZ theory provides a new ways of thinking to mathematical modeling. TRIZ theory has its unique forty principles: the principle of asymmetry, the principle of association, the principle of anti weight, the principle of local property and so on. Take one of them as an example. The principle of multi-function, as its name implies, is that an item has multiple functions. The evolution of the foolish mobile phone to the smartphone is a good example. The original foolish mobile phone only has the function of making calls, with the development of society, this single function mobile phone unable to meet people's needs, and thus has developed smartphones with multiple functions such as touch screen and video chat. Each of these forty principles corresponds to a train of thought. Imagine if we master these forty principles one by one, then problem-solving ideas will quickly emerge in mathematical modeling competitions. At the same time, the multi-directional nature of problem-solving ideas can improve our problem-solving speed, thereby saving us more time and solving more difficult problems in mathematical modeling competitions, from this, it can be seen that successfully completing the mathematical modeling competition cannot leave the help of TRIZ theory.

TRIZ theory provides new methods for mathematical modeling. The TRIZ theory includes innovative thinking methods such as the STC operator method (RTC operator method), the goldfish method, the dwarf method, and the multi screen method, these non inertia thinking methods allow us to break through conventional thinking to see problems and think in new ways. That in various scientific fields, we can use more flexible thinking and innovative methods to invent and create, thereby contributing to different scientific fields, it can achieve the goal of improving scientific level and promoting the field development. It can be seen that the application of TRIZ theory in mathematical modeling can achieve the ideal state of multiple solutions to one problem. At the same time, due to the innovation of the method, it can also simplify the problem-solving process, and obtain the solution in a more direct way. It can be seen that through TRIZ theory, we can greatly reduce problem-solving time and complete competition tasks with high quality and efficiency.

TRIZ theory provides new results for mathematical modeling. The TRIZ theory not only involves the forty principles and many innovative thinking methods, but also applies contradiction matrix tools, technological evolution tools, scientific effect library tools, and field analysis tools when solving problems. From this, TRIZ theory can be provided and used, whether in terms of principles, methods, or tools. If they are applied in mathematical modeling, we are likely to come up with more innovative solutions, which is what I call new results. Not only limited to competition problems, but also extraordinary solutions can be obtained by applying TRIZ theory to the problems we encounter in daily life.

In summary, TRIZ theory has a significant impact and plays an important role in the learning and competition of mathematical modeling. Due to use the theory can establish problem-solving ideas and methods in a relatively short period of time, whichonehas won valuable time for solving difficult problems, and thereby increasing the chance of winning thetop in the competition.

III. STC OPERATOR METHOD IN TRIZ THEORY

A. Understanding the STC operator

1. The meaning of STC operator

The STC operator method is one of the innovative thinking methods in TRIZ theory, where S represents size, T represents time, and C represents cost. The use of the STC operator requires taking limits on S (size), T (time), and C (cost) through extreme thinking, thereby breaking the mindset and avoiding the limitations of inertial thinking, and obtaining a solution to the problem.

2. Characteristics of STC operator

The STC operator has directional thinking. The use of the STC operator method requires considering three different factors separately for the research object: size, time, and cost. Then, through the limit method, observe the changing characteristics of the research object to obtain a solution.

The STC operator has step rigor. The following steps are required to apply the STC operator:

Step 1: Determine the research object

Step 2: Determine the size, time, and cost of the research object

Step 3: Imagine gradually increasing the size of the research object to infinity（S→+∞）

Step 4: Imagine gradually reducing the size of the research object to infinity（S→–∞）

Step 5: Imagine gradually increasing the time of the research object to infinity（T→+∞）

Step 6: Imagine gradually reducing the time of the research object to infinity（T→–∞）

Step 7: Imagine increasing the cost of the research object to infinity（C→+∞）

Step 8: Imagine reducing the cost of the research object to infinity（C→–∞）

Step 9: Through steps 2-8, eliminate meaningless situations, retain realistic and reasonable ones, and ultimately come up with a solution to the problem

From this, it can be seen that the STC operator considers the problem comprehensively and has rigorous steps.

The STC operator has unique results. Due to the fact that the STC operator belongs to an innovative thinking method of TRIZ theory, it also uses unconventional methods to solveproblems, breaking through old conventions and exploring new ways to think about problems. New ideas and methods yield newresults.

3. Issues to pay attention to when using STC operators

1. Do not confuse the research object, always clarify the research object and remember the requirements of the question during the problem-solving process.

2. When doing questions, it is important to clarify the size, time, and cost of the research subjects, and to limit them separately.

3. Due to the many steps involved in solving the problem, it is not advisable to omit or give up on solving the problem.

4. Due to limitations, in many cases, there is no actual situation after calculating the size, time, and cost of the limit. Therefore, it is necessary to make a choice based on actual situations.

5. Due to the complexity of variables, it is important to not attempt to guess the final answer to the problem during the problem-solving process.

6. When writing the final plan, it is important to associate it with the actual situation and write the plan. It is not simply about size, time, or spending one of them to find a solution.

B. Using STC operators to guide mathematical modeling

The application of STC operators inmathematical modeling can overcomepsychological barriers caused by long-term thinking inertia and break the original thinking constraints, transforming objective objects from the concept of 'inertia' to the concept of'non inertia'. In many cases, the successful solution of a problem depends on how todestroy the existing system and shake ourunderstanding of it. The STC operator can also liberate our thinking and broaden our thinking, and consider problems from multiple perspectives to help us find solutions to problems. It is also used in mathematical modeling learning and competitions. Now, let's give two examples to demonstrate the STC operator in guiding theprocess of mathematical modeling (And reflectthe universality of STC operator application):

Example 1: With the increasingly severe greenhouse effect, the government has decided to plant trees and forests on 60000acres of mountainous areas. A total of 600 people will be hired, with an average daily labor cost of 60000 yuan and an average cost of 100

yuan per tree. Each tree covers an area of 6square meters, and an average of 6000 trees will be planted per day. Using the STC operator, we will discuss when to complete theafforestation task with the least cost and whatis the minimum cost? (Regardless of the distance between trees)

Because the application of STC operator needs to seek the limits from three angles of size, time and cost, so we can know the object defamiliarization, which helps us quickly find the breakthrough to solve the problem. Then, through the analysis of the limits from threeangles, we can reposition and comprehensively understand the research object, familiarize the defamiliarization object, and finally find the solution to the problem.

The steps to solve this problem are:

1. Imagine gradually increasing the size of the object to infinity. The area occupied by trees is relative to the total area of mountainous areas.If the area occupied by trees is larger than that of mountainous areas, the problem will not be solved.

2. Imagine gradually reducing the size of the object to infinity. Compared to the mountainous area, the area occupied by trees tends to be infinitely small, so if the mountainous area will plant an infinite number of trees, the manpower and material resources consumed cannot be calculated, and the money spent is also infinitely large.（W→+∞）

3. Imagine gradually increasing the time of the object to infinity. The labor time is infinite, the expenditure on labor costs is infinite, and the number of trees required is infinite, so the money spent is also infinite.（W→+∞）

4. Imagine gradually reducing the effect of an object to infinity. If there is less labor time, the labor cost will be reduced, and the number of trees planted will decrease accordingly, thus losing the purpose and significance of afforestation.

5. Imagine increasing the cost of the object to infinity. The cost of trees is infinite, so the total amount is infinite.（W→+∞）

6. Imagine reducing the cost of the object to infinity. If the cost of trees is infinitely small, the total amount required is

approximately equal tothe total labor cost.

According to the question, the total amount is equal to the total labor cost plus the total trees Cost. The calculation of total labor cost needs to use the ratio of land area to obtain the required time and then multiply it by the required labor cost for one day. The calculation of total tree cost needs to use the ratio of mountain area to obtain the total number of trees needed and multiply it by the cost of one tree.

establish the formula: $\mathbf{W} = \frac{\mathbf{Sz}}{\mathbf{Sn}} \times \mathbf{Wt} + \frac{\mathbf{Sz}}{\mathbf{Sg}} \times \mathbf{Wg}$

S:Sz ,Sn

T:$\frac{Sz}{Sn}$

C: Wt，Wg，W

W:total cost

Sz:total mountainous area

Sn:the average daily occupied by planting trees

Wt:one day labor cost

Sg:one tree covers an area of land

Wg:one tree cost

In summary, when relevant personnel provide tree seedlings for free, the government spends the least, about 66.7 million yuan.

Example 2: If humans were to develop the moon, it would be necessary to continuously transport lunar resources to Earth. Using the STC operator to discuss under what conditions the gravitational force between the moon and Earth changes and the moon's cycle changes after lunar resources are transported to Earth.

establish the formula:

$$F = G\frac{m_1 m_2}{R^2}$$

$$T = \sqrt{\frac{4\pi^2 R^3}{GM}}$$

F: universal gravitation

G: gravitational constant

R: rail radius

M:$m_1 or m_2$

m_1: the mass of the moon before transportation

m_2: the mass of the moon after transportation

The steps to solve this problem are:

1. Imagine gradually increasing the size of the object to infinity. When the transported lunar resources are infinite, due tom_1+m_2=C,m_1 decreases significantly, we can know that $|m_1 - m_2|\uparrow$, so F→-∞, T→+∞.

2. Imagine gradually reducing the size of the object to infinity. When the transportation of lunar resources is infinite, thenm_1,$|m_1 - m_2|$is approximately constant, so the change in F is minimal and shows a decreasing trend, while the change in T is also minimal and shows an increasing trend.

3. Imagine gradually increasing the time of the object to infinity. At this point, there are two situations: the first is that there are many lunar resources transported over a long period of time. Then due to m_1+m_2=C,$m_1$decreases significantly, indicating that $|m_1 - m_2|\uparrow$, then F→-∞, T→+∞. In the second situation, although it takes a long time, transports less lunar resources. m_1 decreases slightly, $|m_1 - m_2|$ increases slightly, so the change in F is minimal and shows a decreasing trend, while the change in T is also minimal and shows an increasing trend.

4. Imagine gradually reducing the time of the object to infinity. At this point, there are also two situations: the first is that there are fewerlunar resources transported in a short period oftime.$m_1$decreases slightly, $|m_1 - m_2|$increases slightly, so the change in F is minimal and shows a decreasing trend, while the change in T is also minimal and shows an increasing trend. In the second situation, which is short in time but transports more lunar resources. Then due to m_1+m_2=C, $m_1$decreases significantly, indicating that$|m_1 - m_2|\uparrow$, so F→-∞, T→+∞.

5. Imagine increasing the cost of the object to infinity. There are three situations: the first is that there is sufficient financial preparation, but there are not many lunar resources needed, so m_1 decreases slightly, $|m_1 - m_2|$ increases slightly, so the change in F is minimal and shows a decreasing trend, while the change in T is also minimal and shows an increasing trend. In the second situation, if there is enough money and the required lunar resources are also abundant, then due to m_1+m_2=C ，m_1 decreases significantly, indicating that $|m_1 - m_2|\uparrow$, so F→-∞, T→+∞. In the third situation, with less money, the ability to transport lunar resources is limited, resulting in less lunar resources being taken away, $m_1$decreases slightly, $|m_1 - m_2|$ increases slightly, so the change in F is minimal and shows a decreasing trend, while the change in T is also minimal and shows an increasing trend.

6. Imagine gradually reducing the size of the object to infinity. There are two situations: the first type requires less lunar resources, so m_1 decreases slightly, $|m_1 - m_2|$ increases slightly, so the change in F is minimal and shows a decreasing trend, while the change in T is also minimal and shows an increasing trend. The second type requires more lunar resources, due to m_1+m_2=C, m_1 decreases significantly, indicating that $|m_1 - m_2|\uparrow$, so F→-∞，T→+∞.

Based on the above six situations, it can be concluded that regardless of the amount of lunar resources required, the gravitational force between the moon and Earth will decrease, and the lunar cycle will also increase. It is only a matter of the magnitude of the change.

CONCLUSION

The TRIZ theory has a profound impact on mathematical modeling. We know that innovation is the first driving force behind development, and any field that wants long-term development cannot do without innovation. Therefore, the innovation that TRIZ theory possesses is necessary for various fields, and of course, it is also necessary for mathematical modeling. Moreover, due to the consistency of the ideal solution between TRIZ theory and mathematical modeling, we can organically combine the two to facilitate learning and deepen our understanding of the two. This article mainly demonstrates the impact of TRIZ theory on mathematical modeling through two examples: the STC operator method in the innovative thinking method of TRIZ theory and the use of TRIZ theory to guide mathematical modeling problems. This article also uses reasoning to explain the role of TRIZ theory in mathematical modeling to assist in demonstrating the impact of TRIZ theory on mathematical modeling. At the same time, the innovative ideas and methods of TRIZ theory reflected in this article play a guiding role, assisting thinking, and providing ideas in the learning and competition of mathematical modeling, and have a positive impact on the exploration of ideal solutions.

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