

# 天津大学



**SCHOOL OF ENVIRONMENTAL SCIENCE AND  
ENGINEERING**

## **Innovation theory method & Ecological protection practice Course Report**

**TOPIC:** Developing Environmental Protection Industry Based  
on TRIZ Theory

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Submission Date: January 17, 2021

## **Abstract**

TRIZ theory is considered as a kind of innovative theory, which mainly functions in solving contradiction. This methodology, based on technical system evolution, is comprised of various types of methods, calculations in aspects of solving technical problems, innovative exploration, as the problem comprehensive solving system. And this system mainly includes 4 separation principles, 8 technical evolution models, 39 general engineering parameters, 40 inventive principles, 39×39 solving contradiction matrix, 76 standard solutions, the algorithm of inventive problem solving (ARIZ), engineering knowledge effect base, a series of comprehensive methodology system. TRIZ theory has been applied into more and more fields, such as management, society, and also is useful of environmental protection industry with characteristics of uncertainty confliction, interdisciplinary and so on.

It is well-known that environmental protection industry has becoming more and more important in national economic development and industrial structure adjustment. This kind industry has exhibited both economic and environmental protection characteristics, and been paid great attention by the nation and public. Developing environmental protection industry is not only helpful for increasing economic value, reducing environmental loss, but also functional in technical and social development, and research in developing environmental protection industry is so meaningful in theoretic and empirical aspects.

Therefore, the report aims to take environmental protection industry as research subject, based on TRIZ theory, choose to use contradiction solving principle, which is solving confliction due to two conflicting requirements to the same element in a system, analyze its availability in environmental protection industry, then assess each main impact element of environmental protection industry, according to the result, establish the confliction matrix of characteristic parameter system, in the course of parameter principle explanation applied in environmental protection industry field, research the model of developing environmental protection industry, so as to put forward innovative theoretic and empirical demonstration in environmental protection industry development.

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# 1. Introduction

TRIZ theory in Russian means inventive problem solving, in English it is short for TIPS, and was put forward by Genrich S. Altshuler (1926-1998) and a series of researchers in 1946, based on analyzing and researching more than 250,000 patents all over the world. Genrich S. Altshuler has concluded that in the back of invention, innovation is neither the inspiration nor exploration in random, but a kind of general rules existing to solve the problem, which can work for telling people what methods or steps can be taken to innovate, and how to forecast or control those results, at last he established this methodology. Until late 1990s, TRIZ theory has spread in countries of the European Union, and in 1997 this methodology was brought into Japan, later South Korea, Bulgaria, India, almost 10 countries began to research on TRIZ theory one after another.

This methodology has been used with other quality engineering technologies, made great contribution in developing products and complete innovative theories, changed traditional technical innovation way which depended on experience and inspiration into the recent way, according to technical evolution rule, and also become hot research emphasis in international technical innovation and quality engineering fields. So many super-companies have begun to apply TRIZ for product innovation, and in the past years, in Sony, Motorola, HP, Samsung, there has been more than 30 percent profit created by innovative strategies.

TRIZ researchers in America has found that there will be much more investment return if the application of TRIZ theory is used in commerce or management fields besides in technology.

Darrell Mann (2004) points out that TRIZ theory can offer the useful systematic definition and the framework for solving problems in aspects of commerce, management and human resources, most TRIZ tools and methods can directly function in non-technical fields, or by made a little amendment, which can become special and systematic innovative method, associating with other management problems and solving methods. Darrell Mann frequently mentions that the 40 technical principles can also be used in commercial field, certainly there are so many problems existing that are required to be solved, such as commercial confliction matrix, non-technical definition. Boris Zlotin works out that in TRIZ theory, first, most common methods in evolution system Altshuller put forward, can be used in non-technical

fields, and finally these can become the normal definition of evolution model; second, analytic tools and psychological elements can directly function in non-technical fields, or making a little change; third, although recent tools come from technical information, extracting course indicates that some inventive principles still can be applied commonly, like converting, dividing, changing bad into good, power, self-service and so forth, meanwhile others can also be changed into application in other fields.

Recently TRIZ theory has been widely used in more and more non-engineering fields, including commerce, sociology, quality management, education, service operational management, finance, marketing, architecture, food technology, software developing, micro-electronics, chemical industry, and so on, and many researchers have made relative explanation to innovative principles in different fields.

## **2. Technical confliction and solving principle in TRIZ theory**

### **2.1. Definition of technical confliction**

Technical confliction means that in the system when one aspect is improved, another one will appear bad result, for example, if increasing the engine power of the airplane, accordingly, its weight will absolutely increase, which is not the expectable result. Technical confliction usually happens into two sub-systems of the same system; some situations will happen as follows:

A        When bringing a useful function into one sub-system, it will lead to the bad function appearing or becoming strong in another sub-system.

B        When eliminating a bad function in one sub-system, it will cause the useful function changing bad in another sub-system.

C        When strengthening the useful function or weakening bad function in one sub-system, it will result in the complexity in another sub-system or even in whole system.

## 2.2. Solving principle of technical confliction

By analyzing patents all over the world, TRIZ researchers have found that in the past, different fields separately used limited rules, and some rules were used frequently, which could be widely used in so many fields. Although these principles refer to aspects of physical, chemical, and other principles of engineering fields, they are still suitable for inventions in other different fields. Therefore, the 40 inventive principles Altshuller concluded that have been proved so important to induct people for invention, have also been called inventors' ideal "inventive plant". Moreover, these principles are playing great role in using technical confliction matrix to solve technical confliction problems, and table 1 is the list of 40 inventive principles, which are widely used in aspects of commerce, sociology, architecture, food, micro-electronics and so on.

**Table 1 Inventive principles of TRIZ theory**

Number	Name	Number	Name
1	Dividing	21	Urgent action
2	Extracting	22	Changing bad into good
3	Partial quality	23	Feedback
4	Symmetrical change	24	Medi-matter
5	Incorporating	25	Self-service
6	All-purpose	26	Copying
7	Nesting	27	Cheap substitution
8	Weight compensation	28	Substitution of mechanism system
9	Retroacting beforehand	29	Gas or liquid driving structure
10	Pre-maneuverability	30	Flexible shell or pellicle
11	Preventing	31	multi-apertured material
12	Equipotential	32	Color change
13	Reversing	33	Well-proportioned
14	Curved surface	34	Discarding and repairing

15	Dynamic	35	Parameter change
16	Missing or over function	36	Transformation
17	Dimension change	37	Hot expanding
18	Shaking	38	oxidant
19	Periodic function	39	Inertia environment
20	Continuity of effect	40	Compound material

### 2.3. Confliction solving matrix

Inventive principles generally function as the tool box, we can choose suitable rules in the tool set, in order to find ideas for solving problems. Certainly establishing confliction matrix is more efficient than this way, in the confliction matrix, there are 39 standard engineering parameters respectively corresponding to different kinds of conflictions, and the establishment of relationship between the parameters and inventive principles is shown in table 2.

The confliction matrix consists of 40 horizontal lines and 40 vertical lines, the first horizontal line represents worsen parameters, while the first vertical line means improving parameters, besides these, other 39 horizontal lines and 39 vertical lines compose the matrix, each element in the matrix shows the principle number which will be corresponding to worsen and improving characteristics. And the course of application includes that firstly choosing worsen characteristic parameter in horizontal line 1, then choosing improving characteristic parameter in vertical line 1, these two numbers can determine matrix element in the across place, and this element will represent the inventive principle number put forward being taken.

**Table 2 Confliction parameters**

Number	Characteristic parameter	Number	Characteristic parameter
1	Weight of mobile object	21	Power
2	Weight of static object	22	Energy loss
3	Length of mobile object	23	Matter loss
4	Length of static object	24	Information loss
5	Area of mobile object	25	Time loss
6	Area of static object	26	Amount of matter or object



7	Volume of mobile object	27	Reliability
8	Volume of static object	28	Test precision
9	Speed	29	Manufacture precision
10	strength	30	Impact on object from exterior bad factor
11	Stress or pressure	31	Bad factor caused by object
12	Form	32	Manufacture
13	Stability of structure	33	Maneuverability
14	Intensity	34	Servicing
15	Action time of mobile object	35	Adaptability or all-purpose
16	Action time of static object	36	Complexity of equipment
17	temperature	37	Difficulty in supervising and testing
18	Illumination intensity	38	Automation level
19	Energy of mobile object	39	Productivity
20	Energy of static object		

### **3. Innovative application of technical conflict principle in environmental protection industry based on TRIZ theory**

#### **3.1. Choosing characteristic parameters of environmental protection industry**

It is meaningful to choose suitable conflict solving principles for solving problems in environmental protection industry. According to technical conflict matrix, we can connect 39 engineering parameters in the conflict matrix and 40 inventive principles connecting with environmental protection industry, establish relating relationship, in order to solve various kinds of conflicts in environmental protection industry development, especially, the key course is to search for balance position between vertical control and horizontal coordination.

Based on TRIZ theory, for environmental protection industry development, it is necessary to pay more attention to problems including, firstly, the service object, namely the position of environmental protection industry, it is so important to determine the service object which means clear industrial, company and product positions, and also useful for allocating resources

into projects of regional preferential development; secondly, investment, means which way the public capital will be chosen to invest, it is helpful to choose practical and advanced productive and service projects, based on functional position of environmental protection industry; thirdly, the amount of investment, it is necessary to take principles with correctly doing, standing at recent spot, overtaking suitably and sustainable development, associating with regional economic developmental objective; fourthly, establishment and management, namely how to establish modern developmental model of environmental protection industry, it is effective to establish macro-regional economic adjusting developmental plan, middle-industrial strategic plan and micro company developmental plan, three-arrangement structure system; finally, the benefit, means to form industrial benefit model, it is capable of separating benefit models, such as production service, function service, problem solving, information service.

Therefore, the paper tries to establish the innovative developmental model of environmental protection industry, with six general parameter units, total economy unit, resource utility unit, public investment unit, sustainable development unit, technical innovation unit, human resource unit. Based on these units, we can establish strategic matrix of regional economic development, which is the direct tool using economic method to establish developmental model of environmental protection industry. Taking vertical controlling and horizontal coordinating two dimensions as changeable dimensions of six structure parameters, the matrix separately divides two dimensions as vertical and horizontal parameters, rising up vertical parameter value means that parameters have been optimized, while rising up horizontal parameter value means that parameters have been coordinated, and table 3 is the specific meaning of these parameters in environmental protection industry.

**Table 3 Confliction characteristic parameters of environmental protection industry**

Parameter	Total economy	Resource utility	Public investment	Sustainable development	Technical innovation	Human resource
Vertical Increasing		Increasing	Increasing	Increasing	Increasing	Increasing
Horizontal Decreasing		Decreasing	Decreasing	Decreasing	Decreasing	Decreasing

### 3.2. Establishing confliction matrix

According to six structure parameters, we can establish 6×6 technical confliction matrix, in which the horizontal represents enhancing in this dimension, while the vertical means reinforcing in that dimension. As table 4 shown that in the confliction, in the across place there will be a pair of confliction except primary diagonal, after all structure parameters are put into the matrix, we can describe problems with these parameters, according to different situations, search for conflictive parameters, find solving ideas or methods in matrix unit table, based on 40 principles of TRIZ theory, then make coordination suitable for environmental protection development, and finally conclude confliction solving method which can effectively function in solving problems in environmental protection and promote its industrial development.

**Table 4 Confliction matrix of environmental**

	Total economy unit	Resource utility unit	Public investment unit	Sustainable development unit	Technical innovation unit	Human resource unit
Total economy unit						
Resource utility unit						
Public investment unit						
Sustainable development unit						
Technical innovation unit						
Technical innovation unit						

**Table 5 Confliction solving principles of environmental protection industry**

Parameter	Total economy unit	Resource utility unit	Public investment unit	Technical innovation unit	Human resource unit
	unit	unit	unit	unit	unit
	1,3,5,9,10,12,14,23	1,3,5,9,10,17,19,22	1,5,10,16,17,18,23,24	1,2,5,6,15,20,24,27	
Principle	1,3,8,12,15,16,20,24	3,5,6,10,14,16,18,27	26		34,35
	24,27,32	24,25,28,40	28,32		

### **3.3. Applied explanation of parameter principle in environmental protection industry**

#### **A Parameter explanation in total economy unit**

Principle 1 Dividing: regional development, functional region division;

Principle 3 Partial quality: Growth Pole Theory;

Principle 5 Incorporating: cooperating with environmental protection industry and other industries;

Principle 9 Retroacting beforehand: exchanging GDP with green GDP;

Principle 10 Pre-maneuverability: making survey previously before making economic policy;

Principle 12 Equipotential: opening governmental information to solve information asymmetry;

Principle 14 Curved surface: substituting linear model with recycling economic developmental model;

Principle 23 Return: making statistics survey and return;

Principle 24 Medi-matter: developing transportation and information industries;

Principle 27 Cheap substitution: reducing cost with current resources;

Principle 32 Color change: making green certification in Agriculture, developing green food industry. **B Parameter explanation in resource utility**

Principle 1 Dividing: classifying rubbish in order to callback resources;

Principle 3 Partial quality: utilizing resources most efficiently;

Principle 5 Incorporating: substituting traditional engineering material, oil and chemical energy with biomass, this kind of renewable resources;

Principle 9 Retroacting beforehand: making regulations and policies to improve resources utility rate, save energy and reduce pollution;

Principle 10 Pre-maneuverability: making survey of current resources utility;

Principle 17 Dimension change: utilizing rubbish as resources;

Principle 19 Periodic function: using resources seasonable characteristics;

Principle 22 Changing bad to good: recycling rubbish use;

Principle 24 Medi-matter: developing resources utility service industry;

Principle 25 Self-service: power plant using residual hot for hot supply;

Principle 28 Substitution of mechanism system: using substitution of resources and energy; Principle 40 Compound material: associating with up-river and down-river.

### **C Parameter explanation in public investment unit**

Principle 1 Dividing-using BOT way to absorb investment;

Principle 3 Partial quality: avoiding bad behavior in investment;

Principle 8 Weight compensation: balancing investment, avoiding risk;

Principle 12 Equipotential: bringing supervision system in capital operation to make the government know product price;

Principle 15 Dynamic: developing financial, accelerating capital flow in environmental protection industry;

Principle 16 Missing or over function: investing by several times with not enough capital;

Principle 20 Continuity of effect: making sure infrastructure construction and continuing investment; Principle 24 Medi-matter: developing financial service in environmental protection industry.

### **D Parameter explanation in sustainable development unit**

Principle 3 Partial quality: choosing one or some kinds of developed environmental protection industries and driving the leading function;

Principle 5 Incorporating: cooperating environmental protection industry with other industries;

Principle 6 All-purpose: paying attention to economic, environmental and social benefit;

Principle 10 Pre-maneuverability: forecasting problems in future economic development;

Principle 14 Curved surface: developing recycling economic industrial chain;

Principle Missing or over function: making high environmental standards to recover environment;

Principle 18 Shaking: choosing or optimizing developmental model according to middle and long term demand of national and market;

Principle 27 Cheap substitution: taking developmental model of low cost, low pollution and low consumption;

Principle 28 Substitution of mechanism system: advocating living way with low carbon and environmental protection;

Principle 32 Color change standardizing environmental protection knowledge for environmental protection industry development.

### **E Parameter explanation in technical innovation unit**

Principle 1 Dividing: service outsourcing of non-core technologies;

Principle 5 Incorporating: developing association with industry, university, technical and scientific research institution;

Principle 10 Pre-maneuverability: forecasting technical development future;

Principle 16 Missing or over function: investing most scientific research power to make progress as soon as possible;

Principle 17 Dimension change: applying various subjects into environmental protection industry development;

Principle 18 Shaking: using scientific, technical and resource advantages for technical innovation;

Principle 23 Feedback: making consumer interview in time;

Principle 24 Medi-matter: developing patent so forth for technical innovation achievements application; Principle 26 Copying: bringing advanced technologies from abroad or other regions.

#### **F Parameter explanation in human resource unit**

Principle 1 Dividing: making separation according to subjects;

Principle 2 Extracting: absorbing experts in fields;

Principle 5 Incorporating: establishing scientific and management groups based on important project;

Principle 6 All-purpose: training comprehensive human resource;

Principle 15 Dynamic: developing human resource flowing;

Principle 20 Continuity of effect: establishing excellent human resource groups and keeping the continuity-

Principle 24 Medi-matter: developing human resource market, such human resource service departments;

Principle 27 Cheap substitution: using suitable human resource, making short time employment;

Principle 34 Discarding and repairing: hiring or firing human resource;

Principle 35 Parameter change: making soft management in environmental protection industry.

### **3.4. Process of technical confliction matrix innovation in environmental protection industry**

Specifically, the process of technical confliction matrix innovation in environmental protection industry mainly includes following twelve steps:

- (1) Defining developmental model system of environmental protection industry development which needs to be optimized;
- (2) Making sure primary functions parameters which needs to be optimized;
- (3) Listing key subsystems and various functions of parameters which needs to be optimized;

- (4) Describing the operation of parameters which needs to be optimized;
- (5) Making sure improving and eliminating characteristics;
- (6) Re-describing relating parameters by seven general parameters;
- (7) Describing technical confliction, if improving a parameter, which parameters will become worsen;
- (8) Describing technical confliction in another way, if weakening worsen parameter, either weakening parameter which will be improved, or strengthening another worsen parameter;
- (9) Making sure matrix elements by both conflictive parameters in the confliction matrix;
- (10) Choosing useful principles according to elements above;
- (11) Applying chosen principles into problems in environmental protection industry;
- (12) Searching for and assessing developmental way to optimize industrial developmental model.

Usually we can choose not only single principle but several ones, because these principles only represent certain possible ways, in other words, we use these principles removing impossible principles, and applying them into solving problems in environmental protection industry as many as possible. Do not refuse to take any possible principle, and if none of possible principles are suitable for solving problems, we need to redefine confliction matrix and get solutions.

For example, when there is limited resource, low utility rate in one region, it is necessary to innovative developmental model to improve resource utility. If taking improving resource utility as vertical parameter, while public investment as horizontal parameter, it will produce the confliction, when there may be possibility that public investment in short time can not be got back, investors will be willing to reduce this investment. In traditional way, there is no way to coordinate the pair of confliction, however, in confliction matrix of TRIZ theory, there are possible inventive principles in the unit table, according to local situations of environmental protection industry, we can associate resource utility unit with public investment unit, so as to solve this confliction, also make innovation in environmental protection industry development.



Table 6 Confliction matrix of environmental protection industry

	Total economy unit	Resource utility unit	Public investment unit	Sustainable development unit	Technical innovation unit	Human resource unit
Total economy unit		5,9,14,22,24, 40	9,14,15,20,32	3,9,14,16,27,28,32	1,5,16,17, 18, 23, 24, 26	1,2,5,6,15,24
Resource utility unit	1,3,5,10,22,28, 40		1,3,8,9,16,17,19,22 25	—	1,5,7,16 24,26	1,2,5,6,9,15,34 35
Public investment unit	1,3,5,9,32	1,9,10,12,15,16,17 ,20,24		3,5,6,15,18,24,27,28 32	16,18,24,26	1,2,5,6,15,20, 24,27,34,35
Sustainable development unit	1,3,6,9,10,18	—	1,3,12,15,16,20,24		1,5,16,17 24,26	1,2,5,8,15,24
Technical innovation unit	5,10,23,24,27	3,5,9,17,28,40	1,5,15,16,20,16,20	3,10,18,24,27		6,15,24,27,34
Human resource unit	3,9,12,23,27	3,5,9,10,40	1,3,5,6,24,27,34	3,6,10,20,28,35	1,10,16,18, 24,26	

The process of solving conflictions is shown in Figure 1, which takes the confliction of resource utility and public investment units as example.

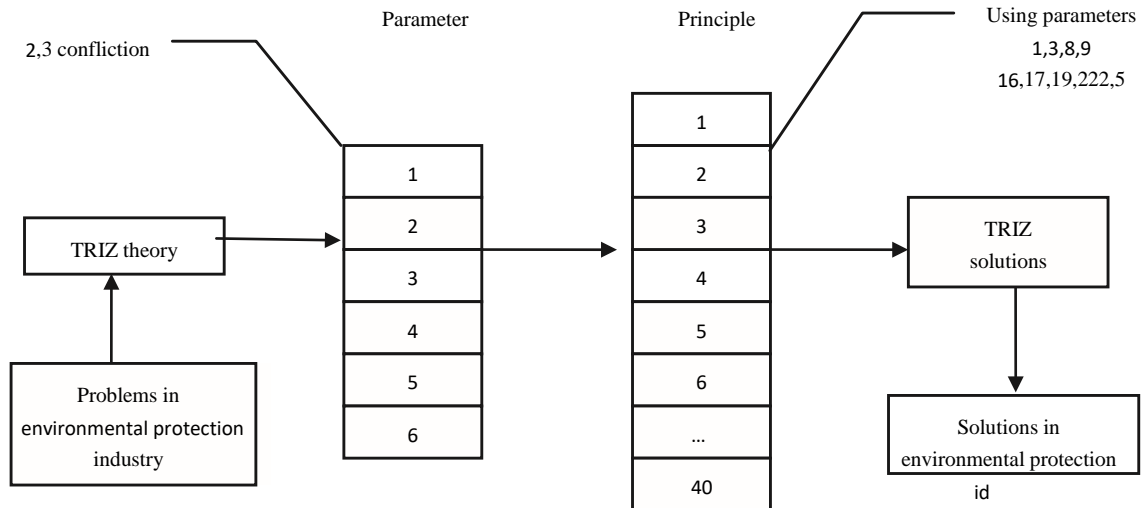


Fig. 1 Process of solving confliction

## **4. Conclusion**

Environmental protection industry is the production which associates with economic system and environmental system, and developing environmental protection industry is the effective way to solve confliction between economic development and environmental pollution. As environmental protection industry coming across two systems, there will have been more various and complicated conflictions, therefore, it is necessary to apply TRIZ theory into environmental protection industry. Although the report has applied technical confliction principle of TRIZ theory, with general parameters and industrial applied principles, and worked out solusions to problems in environmental protection industry development, still other principles in TRIZ theory also can be applied into environmental protection industry, innovate industrial developmental model, such as idealization method, physical confliction method of confliction theory, and we can apply these methods comprehensively, according to current situations of environmental protection industry, in order to effectively solve problems in industrial development and make effort in industrial innovative developmental model.

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