Title:
**Implementation of Low-end Disruptive Innovation based on OTSM-TRIZ**

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Introduction:
Low-end disruptive innovation (LDI) and new-market disruptive innovation (NDI) are two types of disruptive innovation [1]. The LDI is a branch of technological evolution curves in the mature stage [7]. Based on this formation, an innovative product can attract low-end users to quickly meet the market and profit [1], [7]. OTSM-TRIZ is a method proposed to overcome some limitations of TRIZ and manage complex cross-discipline issues. This method is still under development by many scholars for different applications [2-4]. Disadvantaged enterprises in the market can use it to attract a large number of low-end users with a small investment. At present, the disruptive innovation mainly uses the classical TRIZ method, which cannot solve problems of multi-contradictions to meet trend of the product development. The exiting methods of the product disruptive innovation process mare mainly based on the analysis of technology and system evolution [6], [8]. In this research, a LDI development method is proposed based on the OTSM-TRIZ method combined with the analytic hierarchy process (AHP) and Floyd-Warshall algorithm. The proposed method is used in the development of a LDI tire breaker.

Main Idea:
LDI has its own unique characteristics in product development such as relative simplicity, less cost, ease of use, convenience, high reliability and efficiency, and energy saving [1]. Problems of the LDI product development are the data collation and analysis of target products in their mature stage. The aim of this research is to find solutions of the problems and form an analysis modeling method for the development of LDI products.

An initial problem table can be formed for LDI products and related problems can then be transferred into a network of product problems using the OTSM-TRIZ tool as shown in Fig. 1. The network is constructed using the graph theory, where nodes represent various LDI problems Pb or partial solutions Ps, and direct connections represent relations between nodes. In the network of LDI products, some problems can create new sub-problems and partial solutions. These partial solutions may be answered directly using innovative thinking in the final design.

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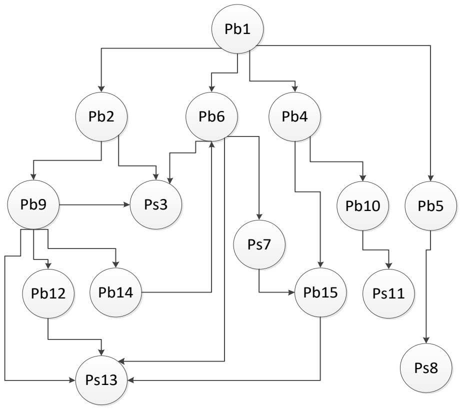



Fig. 1: Network of problems.

Based on the network of problems, key problems can be identified as a series of contradictions. Each key problem is represented by an Element-Name-Value (ENV) model to analyze underlying causes of the key problem as shown in Fig. 2.

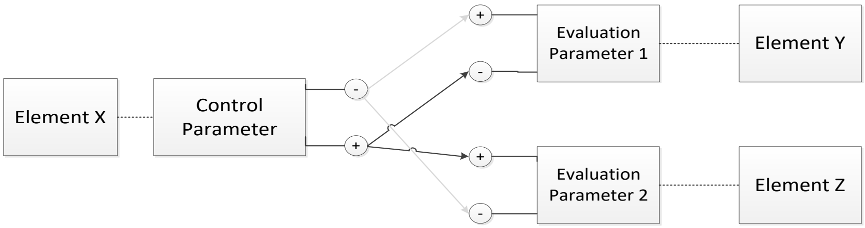



Fig. 2: Elementary model of a contradiction [2].

All the ENV models are integrated together to build a network of contradictions for LDI products. A quantitative analysis of the network of product contradictions is conducted using an analytic hierarchy process (AHP).

The hierarchical structure model is built using the ENV model and network of product contradictions. Each contradiction occupies a certain proportion in practice. The number 1~9 and its reciprocal are cited as a scale to establish a relatively important judgment matrix. Experts use a 1~9 scaling method to compare different contradictions in pairs and then score them. For example, a14 indicates the result of C1 versus conflict C4. The weight coefficient of Ck can be calculated by importing the judgment matrix A after the expert score in the AHP.

According to the ENV model, a technical contradiction consists of one control parameter and two or more evaluation parameters as follows.

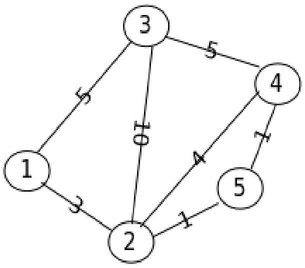
$$TC_k = (CP_k, \mathrm{EP}_{j1}, EP_{j2} \cdots)$$

The proportion of control and evaluation parameters in each contradiction is different in the measurement. Similarly, we use the number 1~9 and its reciprocal as a scale to define the judgment matrix B. Control and evaluation parameters of the same contradiction are compared in pairs by using the 1~9 scaling method. A judgment matrix is formed after the expert discussion and scoring. Weight coefficients of CPk, EPj1 and EPj2 are calculated by importing judgment matrix B in AHP.

The comprehensive evaluation weight coefficient WOk is Wk (the weight coefficient of Ck) multiplied by the sum of WEPki (the weight coefficient of all the corresponding evaluation parameters EPki) as follows.

$$W_{Ok} = \sum_{i=1}^{n} W_k * W_{EPki}$$

Where N is the number of evaluation parameters. When the judgment matrix is CR < 0.1 or $\lambda$ max = n, CI=0, it is considered that it has satisfactory consistency, otherwise, elements in the matrix need to be adjusted for the satisfactory consistency. Because the expert score is very subjective and the scoring matrix is often inconsistent or missing, AHP is used to modify the expert scoring matrix.




| D | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 0 | 3 | 5 | M | M |
| 2 | 3 | 0 | 10 | 4 | 1 |
| 3 | 5 | 10 | 0 | 5 | M |
| 4 | M | 4 | 5 | 0 | 1 |
| 5 | M | 1 | M | 1 | 0 |

| P | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| 1 | 1 | 2 | 3 | 4 | 5 |
| 2 | 1 | 2 | 3 | 4 | 5 |
| 3 | 1 | 2 | 3 | 4 | 5 |
| 4 | 1 | 2 | 3 | 4 | 5 |
| 5 | 1 | 2 | 3 | 4 | 5 |

Fig. 3: Example of using Floyd algorithm.

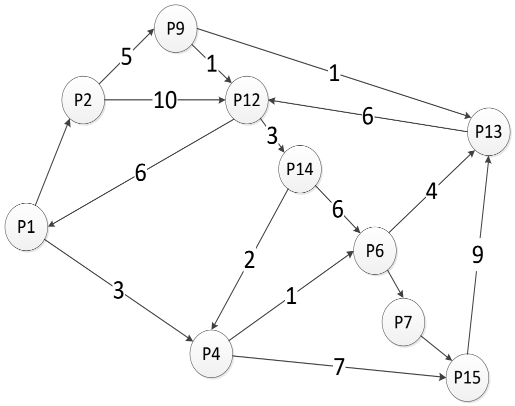



Fig. 4: Example of the network of contradictions.

The Floyd-Warshall algorithm finds the optimal starting point and the shortest path from multiple sources for a given weighted graph as an example shown in Fig. 3. Because the optimal path is the most weighted path, the scheme priority of each path is opposite to the result of calculation. It can also determine the priority of the solution path and the scheme priority of each path as shown in Fig. 4.

TRIZ tools are used to solve key contradictions sequentially based on specific problems of the LDI product. The network of contradictions can be transformed into a corresponding network of parameters. According to the product control and evaluation parameters in the network of parameters, a product can be redesigned based on the structure modification and operation improvement using adding, deleting or replacing. A general network of parameters can then be formed using the objective law and knowledge of the field. The overall flow of the implementation of LDI based on OTSM-TRIZ is as shown in Fig. 5.

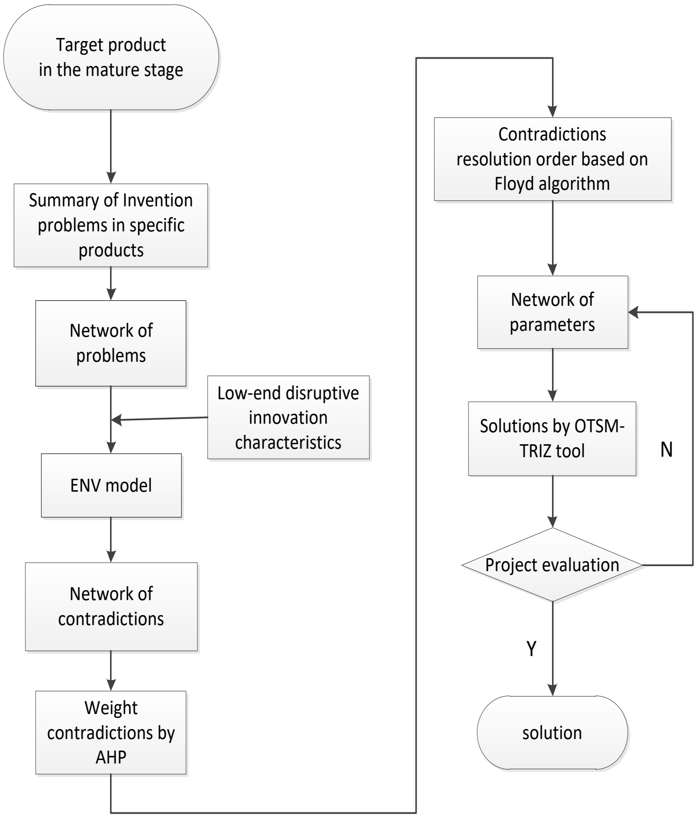



Fig. 5: LDI process based on OTSM-TRIZ.

Case Study:
The tire breaker is a common security device used in maintaining public order and stopping violations of the law. The existing reducer-based tire breakers are usually fixed on the ground. Their structures are complex and not easy for use and operation as shown in Fig. 6. They are also easy to accumulate dust and water, and hard for maintenance.

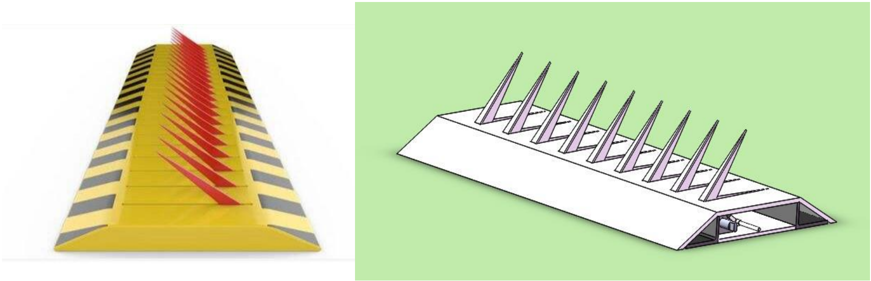


Fig. 6: Existing tire breakers.

Through the technology maturity prediction and analysis of development of tire breakers in their mature stage of product technologies, a LDI product of the tire breaker should have the low cost with reduced height in dimension. Based on the analysis of problems of the existing tire breakers, their structures are abstracted to meet the need of a LDI product. A new design of the LDI tire breaker is proposed as shown in Fig. 7. The new design reduces the number of parts and cost, simplifies the structure of the device, improves installation and operation processes.

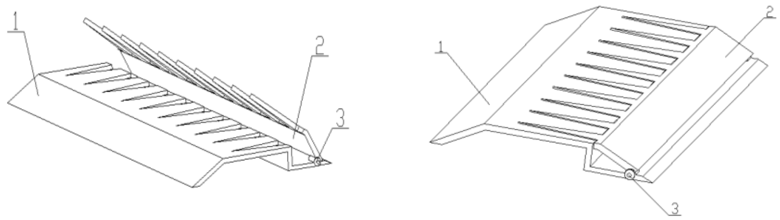



Fig. 7: New design of a tire breaker [9].

Conclusions:

A method is proposed for the development of LDI products based on the OTSM-TRIZ method. The solution search of multi-contradictions of LDI products was demonstrated to provide a guarantee for the contradiction resolution. The Floyd-Warshall algorithm was used in searching the optimal path in the weighted directed graph. TRIZ tools were applied in solving contradictions sequentially in the optimal path. The proposed method was verified in the development of a new LDI tire breaker product.

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