AC 2011-174: NEW PROTOTYPE DESIGN PROCESS INTEGRATING DESIGNING AROUND EXISTING PATENTS AND THE THEORY OF INVENTIVE PROBLEM-SOLVING

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Abstract

To guarantee a higher efficiency in research and development as well as substantial returns on investment, it is essential that corporations reduce the costs incurred by R & D departments. Based on three stages of technological innovation, this paper proposes an integrated process of systematic innovation for redesigning prototypes. This process integrates technology analysis, patent design-around strategies, innovative design methods in the theory of inventive problem-solving, rules of patent infringement judgment, and how to innovate by designing around existing patent. There is a case study that it is expected a redesign of prototypes of light guide panels by design-around strategies to avoid infringement of existing patents can be used to illustrate the integrated process.

Key Words: systematic innovation, design-around, the theory of inventive problem-solving, patent infringement, light guide panel

Introduction

Most of large enterprises adopt a policy distribution of independent technological research and development and innovation, they supply themselves with the innovation achievements or sell to relevant industries to make profits. The enterprises should hold these technical patents firmly to maintain a market position of leading innovation. However, not only large enterprises could plan and practice high-tech R&D and innovation policies; other enterprises could decrease the investments in R&D under the trial-and-error policies. If they could probe and forecast future technical development trend, and they could improve the research and development efficiency and real returns on investment. Therefore, general enterprises could also engage in fundamental researches actively to probe future technical development trend, and accumulate the required core technology capability for future products.

Song and Montoya-Weiss pointed out that although a real and brand-new product development has high risk and uncertainty, it often creates remarkable chances and advantages in competitions for enterprises. They also identified the following six sets of

general NPD activities: strategic planning, idea development and screening, business and market opportunity analysis, technical development, product testing, product commercialization [1]. The new product development is divided into five operational stages according to Crawford, the activities of each stage are carried out according to the result of the previous stage, and in the development process, and the activities of each stage will account for different time ratios [2]. Betz proposed a similar concept of product/technology signpost graph, illuminated the steps and focal points of enterprise's core product and technological development, to be the reference aids for the enterprise or the business department in developing next generation of new products and technology [3]. Morin and Rafferty developed a Technological Resource Management System (TRMS) including six functions: inventory, evaluation, optimize, enrich, surveillance and protect of technology resource [4]. Hamel and Prahalad also proposed a development program similar to the aforesaid six points on carrying out core technology capability [5].

Si & Lee suggests that technology innovation based on designing around existing patent should focus on choosing technology from the target patent of critical technology, the risk of patent infringement and costs of technology innovation and combining the policy of designing around existing patent and the application of TRIZ theory which was created by Genrich Altshuller [6, 7]. Lee, Hsu, & Tu proposed a frame about technological innovation management system that includes technical analysis, technical innovation, and innovated technical value of three stages [7]. In summary, enterprises recognize between three and six critical technological innovation activities or stages from new product ideation to launch.

Therefore, for technological innovation policies of enterprises, how to select prospective and practical technological innovations, and be able to apply effective innovative tools to develop the innovative technology they want, they need to consider this innovative technology could avoid infringement of patents. This idea of technological innovation policy exactly conforms to the primary target of management of science and technology that "do the right things, and do the things right". So, this paper tries to start with technical analysis, technical innovation, and innovated technical value of innovative designing stages, to carry on the regulated design procedure, to analyse and induce the information of patent, to define correctly the question of research, to practice and reach the target of technological innovation in a steady way based on the designing around existing patents. Finally, the practically and effectively new prototype design that it integrated designing around existing patents and the theory of inventive problem-solving is proposed.

Critical Technological Innovative Activities

Based on the case-study of Lee etc. about three stages of technological innovation [7], we extensive identified their specific steps and implementation mechanism of each stage. The eight sets of general technological innovation activities are described as follows.

1. First stage: technical analysis

1.1 Primer Stage Finding: search for potential relevant technologies from industry development trend and relevant technology development. Suggestion: through development trend analyses of industry and product life cycles, or Porter's Five Forces Analysis or development analyses of benchmark enterprises in benchmark theory on relevant industries, or consult experts and scholars about opinions based on Delphi Method.

1.2 Advance Stage Finding: find out all core technologies and involved sub-technologies from enterprise's value chain, and make value judgment according to feasibility principle. Suggestion: make divergent technology search aiming at the level of enterprise's industry in value chain, or identify the critical technology and supporting technology therein based on the technology roadmap[8], or consult experts and scholars about opinions by using the Delphi Method, in the hope of considering the principle that low risk of research and development with low cost.

1.3 Trend Evaluation: determine the potential trend of change in core technology and the value judgment by relevant technology patents or discourse analysis methods. Suggestion: use relevant patent distribution and patent map to critical technologies, or number of theses, quote numbers and distribution of directions in the research of relevant critical technologies, or situation analyses to evaluate risks [9], analyze and judge the potential trend of change in the core technology.

2. Second stage: technological innovation

2.1 Innovation Planning: select relevant key patents as the original sample, and carry out systematic technological innovation planning. Suggestion: use road mapping or stage gate (SG) method, or use technical classification fishbone diagram and efficiency classification fishbone diagram to select relevant key subjects, analyze and draw relevant patent distribution and patent map to key technologies, find out the necessary elements and the connection relation in the main independent claim of patent, convert the forming elements into functional terms and connect them for a system formed by main independent claims.

2.2Execution Innovation: proceed with and procure all innovated technological concepts or models fully and efficiently according to existing technological innovation tools. Suggestion: use theory of inventive problem solving (TRIZ), quality function deployment (QFD), product data management (PDM).

2.3Judge Around Patent: analyze and judge whether newly innovated technology has avoided infringement of patent according to the rule of infringement of patent right. Suggestion: learn about relevant laws to intellectual property, be familiar with patent retrieval, patent map, patent application process, patent infringement judgment and design around technology [6, 10, 11, 12].

3. Third stage: value of innovative technology

3.1Simulate or Experiment: compare the non-infringing innovative technology with previously selected existing technology in simulate or experiment. Suggestion: be familiar with and use the simulation software of relevant innovative technologies to simulate the experimental situation, or construct relevant innovative technology experiments to demonstrate advantages or disadvantages of innovative technologies.

3.2 Apply or Publish: apply or publish innovated technologies to protect technical field and intellectual property rights. Suggestion: for applying innovated technologies, it is required to know and be familiar with the nature of patent, requirements for patent application, types and time limit of patent, realization (embodiment) and exception of patent of invention, audit program and flow of patent application, structure of claim, attribution of patent and limit of patent. For publishing innovated technologies, refer to the process of publishing an academic paper.

For the definition of the eight functional aspects of the frame of the above technological innovation management system, the interactive relationship therein needs a sort of dynamic mechanism of continue improve of conformability, to cover the analysis and execution of core technology innovation policy, as well as focal work of technological management related to innovative technology value. Enterprises can develop conformable technological innovation policies thereafter, and develop and innovate systematic technological innovation management mode aiming at their own core technology abilities. In sum, the frame of technological innovation management system contains three stages: technical analysis, technological innovation and innovative technology value. However, the interactive relationship must be added with dynamic mechanism of continue improve to proceed with continuous innovation of technology effectively.

Integrated Technological Innovative Activities

Hsu, Lee, & Wu are through the related OTFT's patent studying and analyzing to find out OTFT's strategies of research and development [13]. Hsu & Lee have developed several prototype of products by making use some analytical tools of the patent maps and TRIZ (theory of inventive problem solving), and rules of patent infringement judgment [14]. Si & Lee discusses how to select the target patent under enterprise's strategy, before finally taking the designing around existing patent based on patent standardisation as a successful implementation of innovative process [6]. Hu, Su, Lee, Chen, & Chang apply TRIZ methodology to assist product improvement that includes drawing patent maps, applying the methodology of TRIZ to analyze the problems, designing an improved folding bicycle [15].

Based on our extensive case-studies, we identified the following twelve sets of the new prototype design activities:

1. First stage: technical analysis

1.1 Establish Design Proposal: Through inventory of a technological resource, development trend analyses of industry, product life cycles, Porter's Five Forces Analysis,…etc., to search for potential relevant technologies.

1.2 Explosion Patent Search & Analyse Patents Documents: From enterprise's value chain, the technology roadmap, consult experts,…etc., to make technical classification fishbone diagram and efficiency classification fishbone diagram to select relevant key subjects.

1.3 Establish Technological & Functional Matrix: Selected technology in accordance with the depending on technological and functional characteristics of Patents.

1.4 Select Critical Patent: The selected patent is provided with representativeness, typical and key technology; it is a target of patent infringement design.

2. Second stage: technological innovation

2.1 List Main Dependent Items: Using analyze and draw relevant patent distribution and patent map to key technology, find out the necessary elements and the connection relation in the main independent claim of patent, convert the forming elements into functional terms and connect them for a system formed by main independent claims.

2.2 Define or Discovers Harmful Function: Hiatus or deficiency or improvement of patents that are in quotated patents of key patent or patents of the similar technologies regards as the harmful function.

2.3 Expand Formulating Question: The step contains to establish the cause - effect chart and list the question narration. The established cause-effect chart is a relation that links the system of main dependent items and the harmful function. The relation will be presented by narrate.

2.4 Inlet Contradiction-Matrix of TRIZ: Using the invention principle will solve gradually the faceing contradictory design question. The design question has a satisfactory solution, then may start to develop the new design prototype.

2.5 Inspection New Prototypes: New prototypes must have to analyze and judge whether newly innovated technology that it has avoided infringement of patent according to the rule of infringement of patent right.

3. Third stage: value of innovative technology

3.1 Accomplish Prototype: New prototypes that have been avoided infringement of patent were synthesized the last new prototype.

3.2 Simulate or Experiment: The non-infringing innovative technology of the last new prototype compare with previously selected existing technology of the key patent and it’s relational patents in simulate or experiment. It constructs relevant innovative technology experiments to demonstrate advantages or disadvantages of previous technologies.

3.3 Apply or Publish: Apply or publish innovated technologies to protect technical field and intellectual property rights.

While these twelve activities describe a generic integrated technological innovative process, there is considerable variance across projects in terms of the details of each activity. In reviewing the literature, we find that the general conclusion is that the basic skeleton of the technological innovative process is essentially the same in all conditions even though the details of each activity may differ. The integrated technological innovative process is shown in Figure 1. The preponderance of empirical evidence on the determinants of the last new prototype performance suggests that there is a core set of critical activities that are fundamental requirements for success [6, 7, 13, 14, 15, 16].

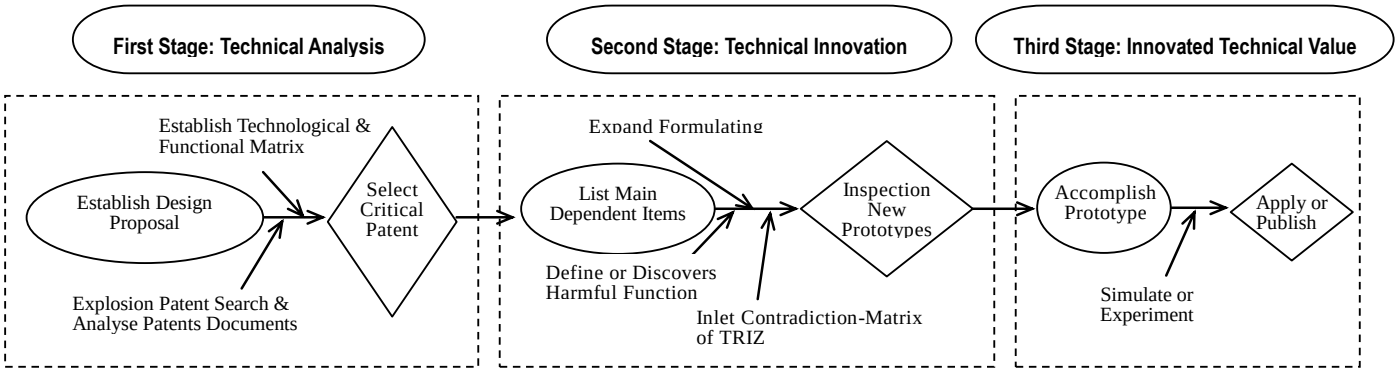

Figure 1: Integrated Technological Innovative Process

In order to successfully execute with the special and complex nature of the technological innovative process for integrated innovation, this process is detailed as a series of operations occurring over three proposed stages: technical analysis, technological innovation, and innovative technology value. The difference between each stage lies in the nature of the research methodology and executing tools. By articulating these processes in the form of a model, we achieve two objectives: (1) we outline a more detailed and comprehensive approach to understanding the nature of the technological innovative process for integrated innovation; and (2) we detail specific propositions for selected research on each stage of the process.

Case study

The steps of applying TRIZ to designing around existing patents is a kind of innovation, which means to design by applying TRIZ to adopting new technologies different from the ones protected in the existing patents to avoid patent infringement as shown in Figure 1. Therefore, the R&D staffs should not only consider whether the innovative design fall into the protected scope of existing patents or not, but also maximize the value of the new design.
First Stage: Technical Analysis (find the target patents)

In a backlight module, the light guide plate controls the brightness and the uniformity, so it determines the output efficiency of the module. Light guide panel is a crucial

component of a backlight module, and is the highest proportion for the material cost of a backlight module, so it is very suitable to design proposal. WIPS, one patent analyzing software, was used to analyze the patents data about backlight module in the US Patent Bureau database and 64 patents related backlight module were found. Then PM Manager, the tool of patent searching in WIPS was used to create a technological effectiveness matrix as shown in Table 1 [16]. Information in the table shows that the optical structure of light guide panel, collecting structure of brightness enhancing film, surface structure of diffusing sheet are the most important point emphasized by competitors in their patent right claims. The optical structure design of light guide panel is collected 22 patents, and is a re-innovation that controls the brightness and the uniformity. Therefore, the patent US5394308 [17] is quoted for the most times (40 times), therefore this patent is chosen as the patent base to improve technology.

Table 1 technological effectiveness matrix of 64 patents related backlight module

			Device characteristics						*Efficiency* *Manufacturing simplicity*								*Cost*			*Reliability*		
Technology	Light condensing	Light diffusing	Prevent flutting and Fixing	Eliminating Moire patterns	Min light beams	Heat resistance	Reduce power consumption	Printing	Etching	Electroforming or Sand-brush	Material mining	Coating	Micro machining	Injection	Simplified structure	Assembly	Reducing agent	Light efficiency	Brightness	Uniformity	Strength
Light source																					
CCFL Electrode	0	0	0	0	0	0	1	0	0	0	0	0	0	0	2	2	0	1	0	0	1
Light guide design	0	2	0	0	2	1	0	0	0	0	0	0	1	1	0	0	0	2	1	2	0
Flat fluorescent lamp	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1
Light guide panel																					
Optical structure	5	5	0	0	0	0	0	4	4	4	0	0	3	5	4	2	1	5	4	4	0
Index of refraction	0	2	0	0	1	0	0	1	0	0	0	1	0	1	1	0	0	3	0	2	0
Film	0	1	0	0	0	0	0	1	0	0	0	2	0	0	2	1	0	3	0	1	0
Lens or Crystal	1	1	0	0	0	0	0	0	0	0	0	0	1	0	1	1	0	0	1	1	0
Light input surface	0	4	0	0	1	0	2	0	0	0	0	0	1	1	0	0	0	1	0	2	1
Distributed pattern	0	0	0	1	0	0	0	1	1	1	0	0	0	1	0	0	0	2	0	2	0
Reflector																					
Shape	1	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0	1	0
Metal layer	0	0	0	0	0	1	0	0	0	0	1	0	1	0	0	0	0	3	0	0	1
Particle coating	0	2	0	0	0	1	0	1	0	0	1	2	0	1	0	0	0	1	0	1	0
Film multilayer	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1	0
Brightness enhancing film																					
Polymerizable composition	1	0	0	0	0	1	0	0	0	0	0	2	2	0	0	0	0	1	1	0	2
Reflective polarizing	1	1	0	1	0	0	0	0	0	0	0	1	1	0	1	0	0	1	1	0	1
Collecting structure	5	5	0	2	0	0	0	0	0	0	1	0	2	2	3	1	0	5	5	4	2
Diffusion layer	1	1	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1	1	1	0
Diffusing sheet																					
Substrate and Diffusion layer	0	2	1	1	0	2	0	0	2	2	3	2	0	0	0	0	0	2	0	3	2
Particle form	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1	1	0
Surface structure	5	6	0	0	0	1	0	0	0	1	3	3	3	2	3	0	2	5	4	4	1
Frame																					
Support	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	2
Groove	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2

Second stage: technological innovation

Based on the optical structure of light guide panel of the patent US5394308, there are formed by main independent items as shown in Table 2.

Table 2 constitutive components of main independent items

item number	component name	item number	component name
1	Cold Cathode Fluorescent Lamp	**2**	reflector of lamp
3	light guide panel	**4**	reflective sheet
5	reflecting surface of light guide panel	**6**	dot pattern
7	dot-density	**8**	emitting surface of light guide panel

After transforming constitutive components into the functionality terminology in the Table 2, we construct an optical structure system of light guide panel that join the

constitutive components as shown in Figure 2.

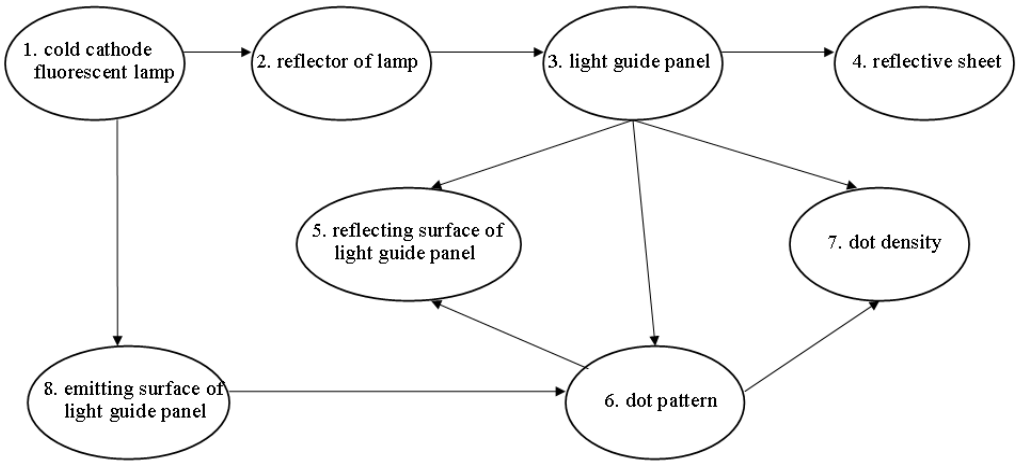

Figure 2 frame of systematization of main dependent items

By literature of similar technical patent [18, 19, 20, 21, 22], the defined or discovered harmful function of the patent US5394308 is that the design of proliferate dot pattern distribution of light guide panel bottom surface cause losses of the light efficiency. Based on the frame of systematization and the harmful function, it improves the correlation harmful function and lists the question narration and establishes the cause-effect chart as shown in Figure 3.

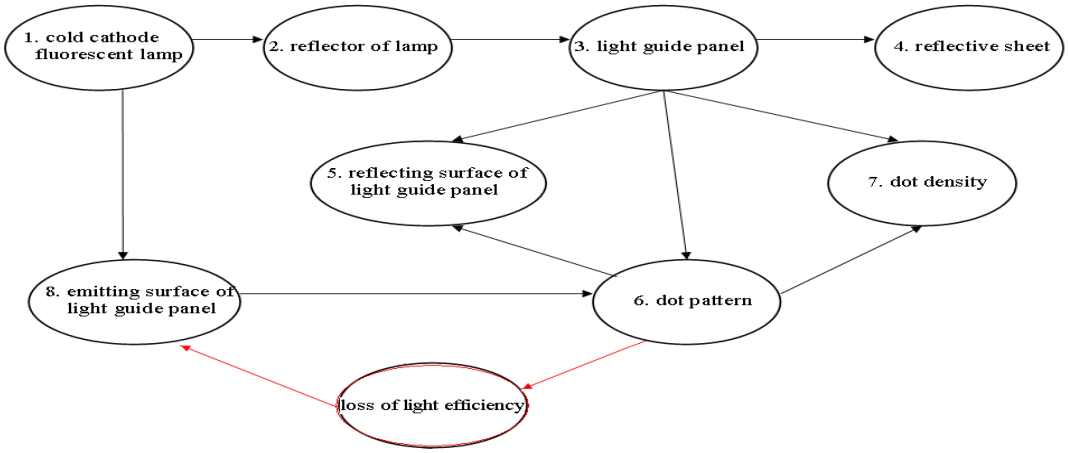

Figure 3 the cause and effect chart of light guide panel

By contradiction-matrix of TRIZ, using the invention principle will solve gradually the facing contradictory design question about that the design of proliferate dot pattern distribution of light guide panel bottom surface cause losses of the light efficiency. There are two kinds of parameters in TRIZ: (18) Illuminance of the improving parameters and (22) Waste of energy of the deteriorating parameters. Using Altshuller Confliction39 x 39 Matrix, which is created (1) Segmentation, (6) Universality, (13) The other way round, and (16)

Partial or excessive actions of 4 creation principles [10, 23]. Further, there are two kinds of parameters in TRIZ: (22) Waste of energy of the improving parameters and (31) Harmful side effects of the deteriorating parameters. Altshuller Confliction Matrix is created (2) Taking out, (21) Skipping, (22) Blessing in disguise, and (35) Parameter changes of 4 creation principles.

Using creation principles of two steps in the design of light guide panel, there are created eight solving concepts of the design of light guide panel. There are five solving concepts that concepts have to analyze and judge whether newly innovated technology that it has avoided infringement of patent according to the rule of infringement of patent right. We find the ideal final result (IFR) to develop the new prototype of light guide panel as shown in Figure 4. The v-cut microstructure on the lower and upper side one dimensional corrugated surface profile are described by equation (1) $Y = 2X - 18$ ($X \geqq 9$) mm , (2) $V = U - 16$ ($16 \leqq U \leqq 29$)、$V = 2U - 32$($U \geqq 29$) mm [15] .

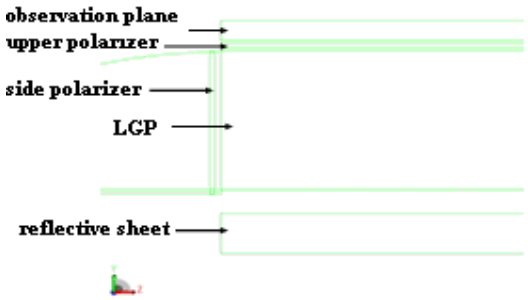

Figure 4 Schematic diagram of a side view of a light guide panel

Third Stage: Innovated Technical Value

In this paper, TracePro optical simulation software was tested to construct a light guide plate of different arrangement of micro-structure. So the systematized procedure of the new design prototypes developed out is used can help the engineer to find the concept of products innovation fast. Offer and develop carrying on one of the systematized important reference methods to innovate of the designer as the group of mould in LCD backlight module of future. The result of study is:

1. The new design of prototype in the light guide panel which developed from the design procedure can improve the light source utilization ratio effectively and the original dot pattern of light guide panel's performance of luminance and uniformity.
2. The arrange regular way of the light guide panel's emission surface M-cut or M-cut micro-structure and W-cut of bottom surface which developed from the design procedure can not only raising the light efficiency of the light guide panel but also improve the luminance's uniformity obviously.

Conclusions and prospectives

This paper analyzes an integrated process of systematic innovation for redesigning

prototypes. This process integrates technology analysis, patent design-around strategies, innovative design methods in the theory of inventive problem-solving, rules of patent infringement judgment, and how to innovate by designing around existing patent. The integrated process of systematic innovation is based on choosing target patent of critical technology, innovating technology and designing around existing patent can be concluded as the follows:

- First, the technical analysis is used to choose the target patent of critical technology for conforming "do the right things ". The technical innovation and innovated technical value is used to design new prototypes for conforming "do the things right ". The innovative designing stages consider both primary targets of management of science and technology.
- Second, the twelve sets of the new prototype design activities is the practically and effectively new prototype design procedure. The operating process of case study can be tested and verified for the practically and effectively integrated process of systematic innovation.
- Finally, the integrated process of systematic innovation for redesigning prototypes can be applied to different enterprises or products. It combines the policy of designing around existing patent and the application of TRIZ theory, and illustrates that the designing around existing patent is a kind of innovation procedure by using OTFT, folding bicycle, light guide panel, LCD backlight module,…etc. cases to certificate.

We hope to integrate the choosing policy of designing around existing patent and the choosing technology of target patent in an integrated structure as much as possible. The further study will develop and improve the given innovation model structure. Therefore, the integrated theory should be more actual application in enterprises.

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