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Research on Capturing of Customer Requirements Based on Innovation Theory

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Abstract

To exactly and effectively capture customer requirements information, a new customer requirements capturing modeling method was proposed. Based on the analysis of function requirement models of previous products and the application of technology system evolution laws of the Theory of Innovative Problem Solving (TRIZ), the customer requirements could be evolved from existing product designs, through modifying the functional requirement unit and confirming the direction of evolution design. Finally, a case study was provided to illustrate the feasibility of the proposed approach.

Keywords: customer requirements; product design; TRIZ; technology system evolution laws; function requirement analysis

1.Introduction

The analysis modeling of customer demand is to connect the market, customers and product development process, is the beginning of the product life cycle[1]. As customers demand's abstraction, complexity and change, it is very difficult to identify its specific forms, and has a direct impact on product design quality and new product development success rates. Therefore, an effective information collection and analysis of customer needs, and then the precise definition are necessary prerequisite for a successful product design. Customer needs analysis effectively or not has become a key factor to shorten product development cycles and improve new product development success rate, it is also the research focus of academic and engineering[2].

This paper first analyzed two capture models of customer demands, its differences, proposed the application of TRIZ evolution of technology systems, through the changes and evolution of existing products to get new idea of product innovation, then through the market ways to obtain information on customer demand, build an analytical model, and finally, the case is given to verify the validity of this method.

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2.Literature review

Currently, there are two models to capture the customer demands: technology-driven model and market-pull model.

2.1.Technology-driven model

Technology-driven model means through the law of technology development and consumer trends to predict, starting from the internal analysis of existing products, technology-driven approach to obtain customer demand, and then determine the product development planning and technical routes. Sony's founder Akia Morita said[3]: "The company's new product development is necessary to guide the user, instead of asking the user what is required, users do not know what is possible, but companies know." Namely, the original product design needs and ideas come from the enterprises themselves, enterprise through self-service technology innovation and product innovation to create new demand or to better meet existing customer needs.

The main application period of technology-driven model is from the mid-50s to the 60s in the 20th century, that is just the recovery period after World War II, and social demand exceeds production capacity, economic growth was mainly driven by new technologies from the enterprise. The enterprises strategy is to product development and production. Starting on the basic theory through research, through product design and manufacturing, a steady flow of product is push into the market, and the market might absorb an unlimited products

Technology-driven model is largely Product-centric, make customers to adapt products and meet the seller's market in commodities.

2.2.Market-pull model

From the late 60s of 20th century, in the developed countries, the production gradually returned to normal levels, the market structure of demand had considerable changes. Enterprises began to face the diversity of customer needs and trends in personalization and provide diversified products to meet the fierce competition. New product development strategy also started gradually to meet the market demand, product innovation research has focused on the market's role in the process, the user needs are considered to be the driving force behind product innovation. The market pull model started to become the main patterns to capture customer needs. The market pull model means through market research and analysis to determine user needs, and then start the product design, and the original idea of design come from the market research results.

2.3.Research Status

At present, the academic community has more study for the market pull model of customer demand. The key is how to overcome the described ambiguity of customer demand, convert accurately the demand to designers' technology needs [4], as a follow-up product design input. Now for those pre-treatment, the main method include regression analysis, cluster analysis, neural networks, AHP and fuzzy sets algorithm, by analyzing the importance of different demands, it is given different weight. Finally, the conversion is complete by the Quality Function Deployment tools etc [5] [6] [7] [8] [9] [10].

The main limitations of market pull model are: first, customers generally use the natural language to descript their demand, highly subjective and arbitrary, thus making the demand discounts the validity of the information, resulting in the discussing with clients repeatedly for the demand information consultation and trade-offs, consuming a lot of time[11]. Secondly, the design sector has a low participation to this process, so the R & D departments tend to believe that the marketing department can

hardly grasp the key to product development, thus providing inadequate demand information, affecting the efficiency of the design. Third, this model take into little account the existing products evolution information on customer needs, leading a lack of objectivity and continuity of demand. Finally, customer demand information have the explosive growth, "information overload" might caused the screening time more longer, and eventually make the product development cycle extended [12].

As the market competition becoming increasingly fierce, customers increasingly important, scholars mainly made more attention for the market pull model, and the research literature of technology-driven model is very small. Literature [13] by analyzing the products of the functional requirements of internal variables, made Variant demand modeling method, and discuss its presence in the power product design applications; literature [14] by analyzing the success of existing products, concluded that product innovation rely on the inherent templates, in product development, use of the template to generate new product ideas, and then conduct market research to determine the need to develop the concept of product design. However, these methods do not take into account the inherent technical system evolution law; there are a certain deficiencies and shortcomings. Technology-driven model research has just begun, and there is no sophisticated structured method.

In the 21st century, customer demand are more difficult to predict, solely dependent on any one model can not accurately capture the customer's demand information, therefore, the integration of market-pull and technology-driven model become the main way to determine customer needs.

This paper studied only the product improved design problem, through the integration of TRIZ substance field analysis tools, function attribute analysis tools and technology system evolution law, starting from the product internal analysis to get the customer demand information, the following is the detailed analysis.

3.Feasibility analysis

3.1.The general process of product design

As shown in Fig.1 [15] ， product design can be seen a continuous mapping process from the customer needs to functional requirements, to the design parameters and process variables. Among them, functional domain mapped customer demand to the product's functional attributes, it is the bridge to connect internal and external customer, not only reflects the internal customers on technical, structural needs (such as manufacturability, assemble, etc.), but also reflects external customers on the use of functional needs. Although the manifestation of customer demand may vary, the nature of the objective is to make products with the corresponding function; function is the nature of survival of the product.

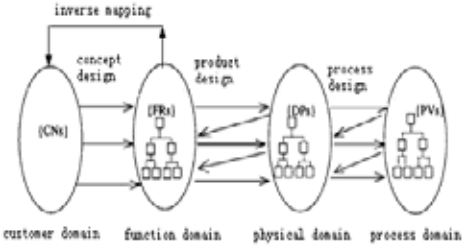

Figure 1 Schematic diagram of the general process of product design

In a highly competitive buyer's market, the market itself has the role of natural selection, products which can meet customer demand will be survive, otherwise be eliminated. Some characteristics of successful product well positioned to meet the some important needs of customers; customer demand left its mark in the product features. As time goes by, the success products encompass a variety of market demand as the material carrier. Moreover, through the analysis of family history of the development of

products, we can get some dynamics of customer needs and preferences.

In addition, the manufacturing industry converted from mass production to mass customization era, making the market very rich range of products, basically covering all aspects of people's lives, these successful products implies a wealth of information on customer needs. Therefore, the customer demands information could be getting through the analysis of the existing functional property from the successful product.

3.2.Technical system evolution law

From the history perspective of the manufacturing development, the product as a technical system has its own evolution rule. Innovative problem-solving theory summed up the technical system evolution rule to guide the new product design and technology forecasting. In TRIZ theory, the evolution of technology systems can be divided into macro and micro levels, each of a macro model at the micro level has a number of routes, these routes identified from a qualitative point of view of the direction of the evolution of technology systems.

Because the product is the physical carrier of customer demand information, the evolution of the product inevitably reflect some changes in customer demand trends. Product design characteristics of this evolution, not only shows that a large number of historical products have certain functional requirements models, but can be applied to analyze the evolution of the functional requirements and changes in product attributes, creating a potential customer needs.

3.3.The evolution of customer demand

In the 20th Century, Dr. Kano in Japan proposed Kano model to represent the evolution of customer demand products [16], as shown in Fig.2. Customer's demands are divided into basic needs, regulatory requirements and potential demand. Basic needs are basic requirements of product function and quality, if the product does not achieve the basic needs, customers would cause strong resentment. There is a linear relationship between regulatory requirements and the quality of products, and the higher of technical level, more satisfaction will be got. Such as the car engine performance and cost are closely related, Limousine has high standards for car engines than regular cars, which is generally easy to understand and do not cause complain too much. The potential demand is not aware of the needs of the user, but it does need to meet. The potential demand is the key for product innovation

As time goes by, the potential demand will gradually converted to regulate demand, and then basic needs. For example, the air-conditioned of cars becomes the basic needs of our customers.

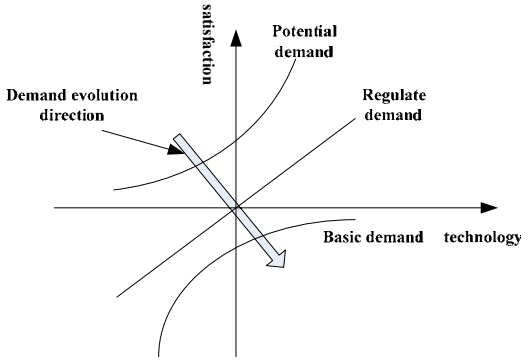

Figure 2 Kano model

3.4.The dissemination laws of potential demand information

One of the purposes of product innovation is to meet the potential customer demand, create new value for customers. But the potential demand information has specific rules for the dissemination, as shown in Fig.3. Generally going through three stages of its spread, in I stage, the potential demand beginning to emerge, but it spread slowly and only some of the customers be aware of its existence. In II stage, the related characteristics gradually become clear, known by most customers, the spread rapid also faster. In III stage, the customer demand information awareness of saturated, spread gradually slow down and stop.

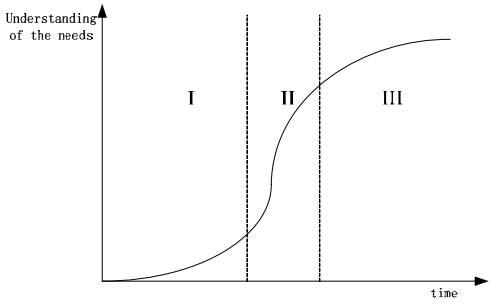

Figure 3 Schematic diagram of the propagation of demand information

Clearly, the best time for companies launch innovative products ahead of the competition is I stage, but because very few customers be aware of the existence the demand at this stage, customers who are familiar with the relevant attributes of existing products would interfere with the expression of its potential demand, so in I stage, through market-driven model to obtain the potential demand is very difficult. In the history of many successful products such as personal computers, Walkman and the emergence of digital cameras are not pulling through the market model to determine the potential demand for information, but the technology-driven results. For this reason, many academics and business managers thought that gather customer needs through market research to develop innovative products, the effect is not always obvious, and it should be emphasized through technical innovation to create the potential customer needs.

In summary, from the internal analysis of existing products to capture the customer demand information has a certain theoretical basis and feasibility.

4.Analysis model based on triz

Analytical framework presented in this paper as shown in Fig.4, the main steps are: 1)firstly, analysis of the functional requirements information within the existing product, to establish its function-level topology, 2) through the use of TRIZ substance-field analysis model, to get the link between system components and basic functions principles, 3) Then combine technical system evolution law to achieve the system evolution analysis of the functional layer and IFR(ideal final result) analysis, get the units that need to improve and be innovative, 4)based on the related resources within the enterprise to select the appropriate changes and evolution of functional design, 5)before the detailed product design, using a variety of market-driven model survey methods, interacting with customers, to obtain complete customer information.

Model proposed in this paper combines technology-driven and market pull the advantages of both models in order to demand the acquisition, analysis, structured and systematic, raising the efficiency and accuracy for customer demand.

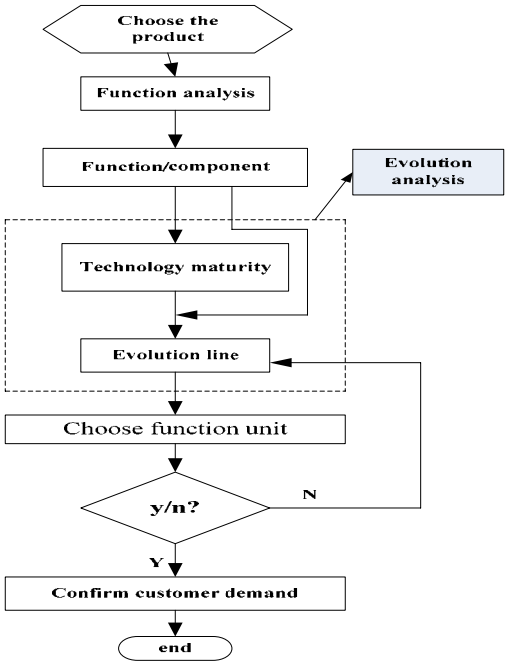

Figure 4 model based on TRIZ

Follows are the main modules:

4.1.Functional requirements analysis

Functional requirements analysis derived from the value engineering theory, that means based on the logical relationship between functions and the functional definition, the overall function of the product gradually decomposed into sub-functions at all levels. Order to avoid the functional decomposition and the form of structural description differences on account of the different function definitions [17], according to TRIZ law of the integrity of technical systems and the product working principle, the overall function is divided into four modules, namely, functional unit of energy produced, the Executive functional unit, the energy transfer function unit and control unit. On this basis, continue to break down into a series of non-overlapping sub-feature set. Given the functional can not be completely independent of the specific product structure exists, the functional requirements decomposition depends on the type of product.

Fig.5 shows the schematic diagram of the functional decomposition of topology, the hierarchical structure fully reflects the logical relationship between the functional requirements. The system function units (FR2) Implemented the main function of the finished product that has the working principle change means that the product has undergone major evolution, but also to determine an important basis for product upgrades and other functional units finished the auxiliary function of the finished product.

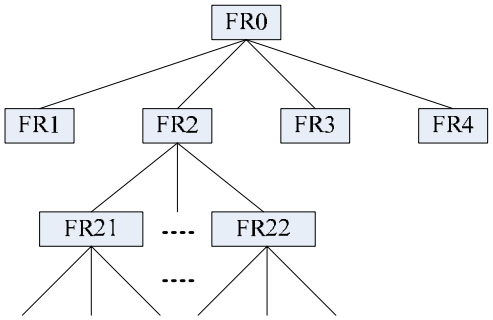

Figure 5 Diagram of functional topology

4.2.Function - Components Analysis of the Relationship

It is not enough only to get the functional decomposition topology diagram, for it can not determine the functional unit needed to improve. So applied of TRIZ substance-field model, this step confirm the harmful function, lack of features, excessive and harmful feature functions of the functional unit, and establish the link between the different levels of products system components, as shown in Fig.6.

In fig.6, a represent the interaction between the components, such as support, driven and so on, and the different connection line between the components represent the various different functional forms, such as, Part 1 on Part 2 adverse features, Part 3 on Part 1 excessive functions. The basic principles of substance-field model refer to the relevant sections of TRIZ book.

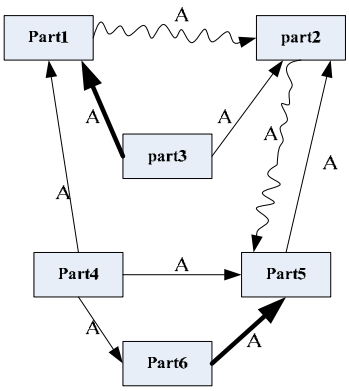

Figure 6 Function / component relationship diagram

4.3.Evolutionary Trends

The analysis of the industrial products historical data shows that as the most popular technology systems follow the TRIZ evolution theory of technical systems, so the future evolution direction could be predicted based on the current phase of the system through select the appropriate evolution line to analysis.

- To determine degree of technological maturity

According to the product's performance changes, the number and level of invention patents, and trend of changes in product sales data etc, the technology maturity and market life-cycle stages of products can be qualitatively determined. For market mature products the replacement technology trend analysis is on priority; for growth stage of the product, while improving the core principles, the evolution

of the auxiliary function is analyzed based on special evolution lines.

- 2．Evolutionary Analysis

For the improve design of subsystems or components to, it is allowed not to determine the maturity of the technology, because the sub-system technology does not represent the core technology of product. Specifically, we can choose a single route or combined lines for the evolutionary analysis. Frequently used lines include: systematically increase the dynamic nature, the macro to the micro-evolution, flexible additional routes, field evolution routes etc.

- 3、The choice of functional unit

After the evolution analysis, we can choose the functional unit which has the evolution potential to carry out the evolution design. Selecting unit is required to observe the following principles: a) enhance the efficiency of products, or at least does not affect the main functions; b) does not produce harmful new features; c) to eliminate harmful features of the original product at the same time does not affect the completion of the main functions.

The so-called evolutionary design refers not only to have a major technological breakthrough in innovative design, but the combination of different functional units, decomposition and reduction, the effect of different fields of application in this field. TRIZ knowledge-based science and technology database is an important evolutionary design support tools, such as the effect of library, the standard solution and so on.

4.4.Resource Analysis and Identification of customer needs

Taking into account business related resources reserves, such as technical capabilities, manufacturing capacity and management capabilities, in collaboration with the corporate marketing departments, to convert the technical language described the functional requirements to natural language used in customers, in order to provide customers with a standardized method of information representation, after interaction with customers to communicate, we can get the customer needs which is possible to achieve.

5.CASE STUDY

After 20 years of development, China's washing machine industry began a new time which has a coordinated production and sales, slow market growth. Technological competitiveness has become a major force promoting the development of the industry [[18]]. In this paper, we choose the most widely used fully automatic top loading washing machine as a case study, the major analysis steps described below:

5.1.Functional decomposition and functional / Parts Relationship

Fig.7 shows the functional unit components / Schematic model of functional relationships based on the functional decomposition and substance-field model analysis. As the figure illustrated, its main function is to convert electrical energy to mechanical energy, Drive pulsator and water currents by acting to complete clothes washing, dehydration, program control and water control are other auxiliary functions. All harmful functions are of pulsator vibration noise, water pollution of washing agent and electricity consumption.

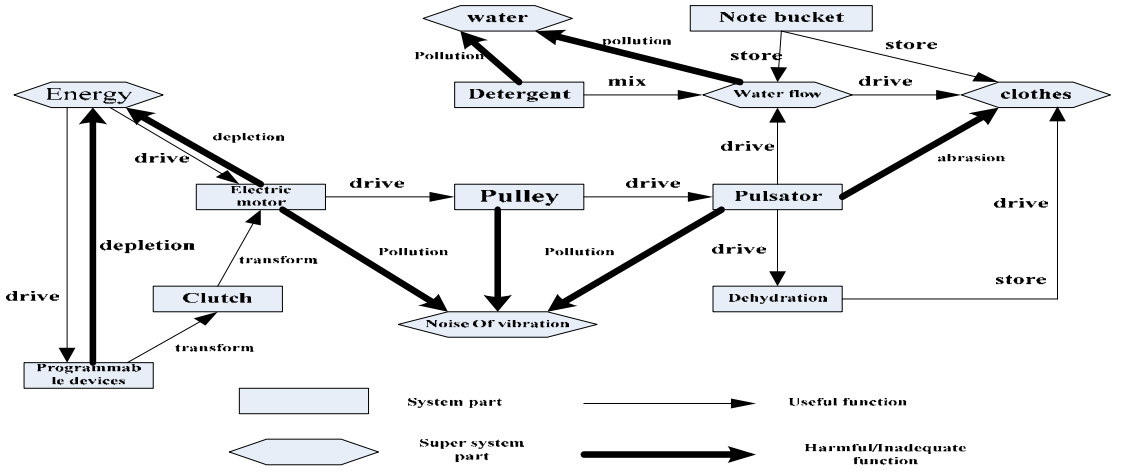

Figure 7 Schematic model of the implementation of functional unit

5.2.Maturity of technology

In this case, the technology maturity are determined by such Variables, including the products production and sales trends, patent analysis, performance and the change rends of the number of competitive companies.

- Production and sales trends

During 1993 to 2007, 14 years, the growth of China's washing machine status became more and more steady, annual growth rate has small fluctuations between 3 to 8% of [19] . The stability of production and sales demonstrated that the market will not be explosive growth unless significant technological breakthrough. Fig.8 for the production and sales trend chart (unit: million units).

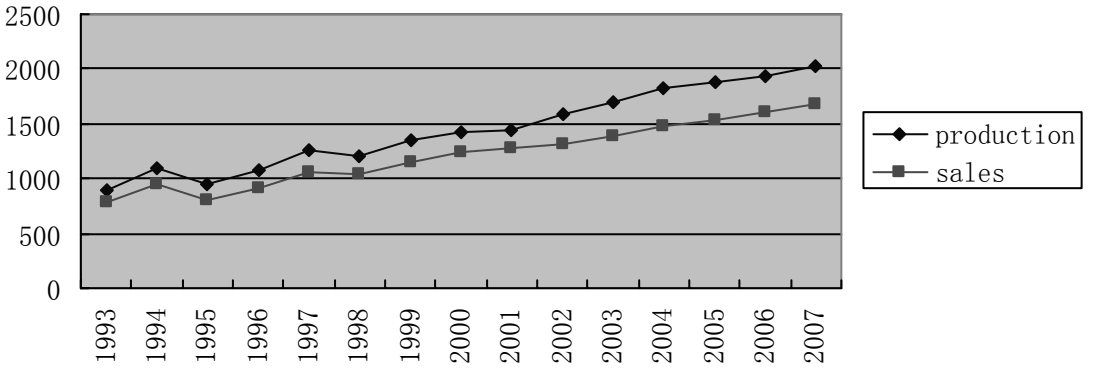

Figure 8 curve of production and sales

- Patent Analysis

By Querying the China Patent Information Center website using key words "washing machine", we can known that the number of approval patents is 3833 from April 1985 to October 2004, as shown in Table 1.

Table 1 the number of patents from 1985 to 2004

Years	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Amount	38	51	65	47	57	71	69	121	102	97
Years	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Amount	109	189	219	284	248	280	398	401	435	452

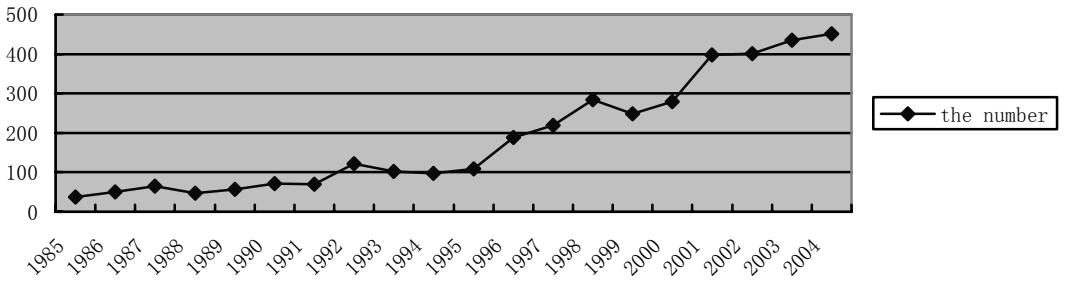

Figure 9 The Change curve of the patents number

As shown in Fig. 9, around 1995 it is clear that the number of patents has the rapid growth, in 2003 reaches the peak. In addition, from the content of the patent, the rapid growth part more concentrated in the accessibility improvements and cost reduction, such as, control, noise reduction, new manufacturing materials, improvement of drainage valves, clothing sterilization and pipelines design improvements, drive motor efficiency improvement and alarm etc, relatively the level of patents lower, and there was little significant improvement patents in regard to washing principles.100 years, the basic principles of washing machines has been the movement of water with detergent-based cleanser to clean the clothing, based on the different drive way the machines are divided into three different types: mixing style, roller, and Wave wheel styles. In future, changes to the basic principles of washing will mean major changes in technology.

- Performance changes

The market survey of washing machine in Nanjing city shows that since 2003 China implemented a "national standard for household electric washing machines" (GB/T4288-2003), the major brands have small difference in six indicators, such as the washing ratio, electricity consumption, water consumption, noise, water content, trouble-free run, and the washing machine performance is very stable.

- The change of washing machine manufacturers

In 1979, the washing machine industry has more than 30 manufacturers in china. In 1980, the manufacturer has increased to more than 100. Early 20th century, the number is more than 1,000 companies. Mainly due to more number of local protectionism and state-owned enterprises transition difficulties under the planned economy, the manufacturers' number of washing machine in China is a little more, but from the view of brand concentration, the market has presented the main features of a mature market. According to statistics, the top three brands(Haier, Little Swan, Royal star) market share was of about 60%, and the distance between the industry first two (Little Swan and Haier) and the third continues to widen. Leading brand of mature, rational and the inelastic demand of washing products are two key elements to decide the technology innovation is more significant and dominated than other features in the washing machine market.

Based on the above analysis, the washing machine has been in the mature life cycle of the market,. While the companies continue to improve on existing features in order to maintain the corresponding profits, they have to carry out product innovation, and find the new core technology which can replace the traditional washing techniques to enable enterprises maintain the advantage in the future competition.

5.3.Evolutionary Trends example

- Macro to micro evolutionary line

The line indicate that the materials structure of technology systems continuously evolved from macro to micro, and within the system the number of energy conversion would reduced, transmission channel shortening, the field resources consuming increasable. The sequence is gravity field, mechanical field, Thermal EMF, chemical field, biological field.

Fig. 7 shows that the energy conversion of wheel washing machine is to convert electrical energy to mechanical energy and through the pulsator rotation to drive clothing acting repeatedly to complete the clothes washing. Applied this evolution, we can obtain a core principle design direction of the washing machines evolution, that is remove the conversion process of electrical energy to mechanical energy, directly use the energy (field) / field to control the water flow to complete the washing function, which can reduce half the energy conversion while eliminating pulsator rotation noise and reduce wear clothing. For example, application of direct drive motor can save the existing drive belt and clutch reduction, and simplify the overall structure and the power transmission mode, realize the power washer direct drive (DD-Direct Drive) and the variable speed function.

- Gradually reduce the human intervention

The history of washing machine also Verified that human interference on the technical systems decreased trend gradually. Initially washing clothes mainly depend on a washboard, wooden club to hand washing, then washing machine was invented to replace the washboard and human clappers, which need human by self shake the handle of the machine and make clothes floating in the liquid soap to complete the washing action. In 1911, the Americans invented the electric washing machine, and after many years continuous development, it was divided three models: mixed-type differentiation, the rolling wheel and Wave wheel, then the emergence of semi-automatic washing machine came. Electric washing machines were still needed human to complete clothes dehydration and wring. In the 1950s, fully automatic washing machine was invented and fully automatic home laundry process completed. Into the 21st century, in control part washing machines used most of the fuzzy control function, into the intelligent stage. To reduce interference from the trend of people, the future development direction will be washing robot that can automatically gather the clothes in family for washing, and complete drying and collection functions, as fig.11 shown.

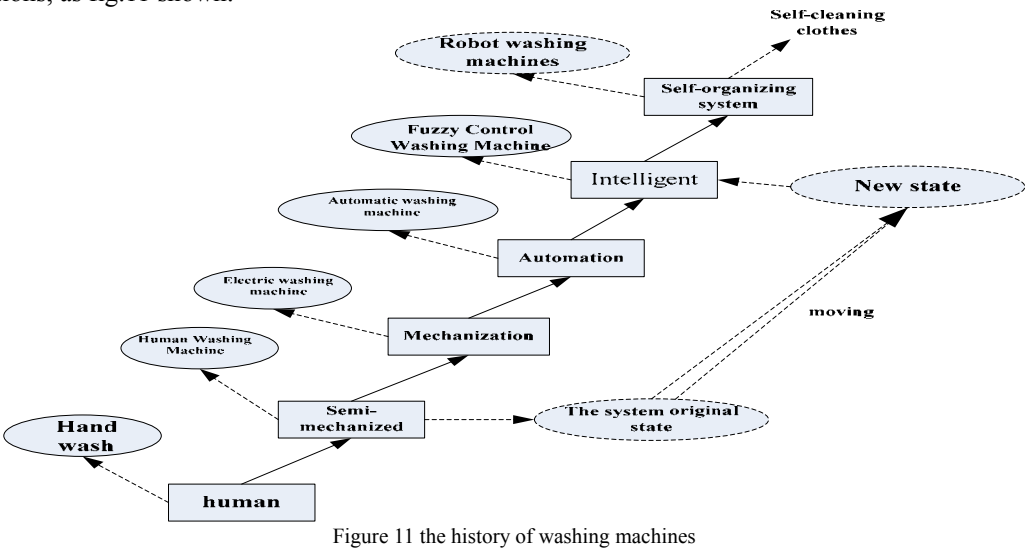

Figure 11 the history of washing machines

- Raise the level ideal line

When we applied this line to analysis functional unit, firstly the ideal list should be confirmed, and

based on the IFR to Reason contrary, and gradually find solutions to the current design solution.

The ideal final result is that clothes do not require washing and can automatically maintain clean, so washing machine is not a real potential customer's needs. This inspired designer make the cloth-depth study of the microstructure to manufacture the clothes need not wash. Now we have not gets the clothing fibers structure to maintain fully automatic cleaning, because the science and technology can not be achieved to reach the ideal solution. Otherwise we can obtain the new washing machine which does not require water and detergent, and water and detergent can be repeated using, reasoned from the reverse ideal solution. As shown in Fig.12. For example, Haier has developed the washing machine which called water cycle and without detergent [20].

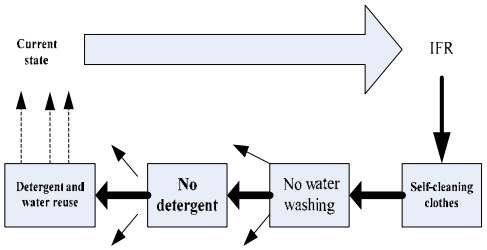

Figure 12 the Ideal evolution line analysis diagram

5.4.Requirements Identification

Through the function / components diagram and trend analysis, we can get the concept of innovative customer needs, as shown in table 2.

Table 2 Innovative concept of customer demand

basic needs,	Low noise, little water pollution, save energy;
regulatory requirements	Thorough washing with clean, quiet (no noise), laundry time is short, no damage to the clothing, automation;
potential demand	No water or detergent, no consume electricity, clean clothes automatically, be dropped off clothing, automatic decomposition of clothing, washing robot

As the general customers do not have the technological evolution of system development knowledge, do not understand the design process of washing machines, and they concern only the power, water, noise reduction etc, and these basic needs indicators, traditional market research also can not obtain the potential demand which. Using the obtained improvement goals of functional unit, the potential customers need can be achieved and give them surprise, such as the washing machine without detergent and water, which would be doubtless to bring detergent industry revolution.

6.Conclusion

The proposed framework model based on TRIZ technology evolution to obtain the customer needs from existing product combines the advantage of technology-driven and market pull methods, hoping to

revise some of the defects of the traditional market research, to shorten product development cycles, improve the success rate of new product design, case analysis shows that this method has some validity. However, this model also has some limitations, such as, the framework model is rough relatively, lack of quantitative in the analysis tools. Along the understanding for design nature more precise, we will modify this model to the eventual realization of the real structured demand capturing.

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