Research and Implementation of Key Technology of Product Functional Design

Guozhong Cao, Runhua Tan and Benning Lian

Hebei University of Technology

Email: cgzghx@163.com
1. Introduction

Functional design, which plays the central role in ensuring design quality and product innovation, is a well-researched and active field of engineering study.

There are various, often conflicting, definitions of function in the literature; no universally accepted definition is currently known.

Researchers have recognized the importance of a common vocabulary for broader issues of design.

Functional composition has been given considerable attention by researchers.

During functional design the design knowledge and technologies in multiple different domains may be employed, and complicated developing activities. Although there are now some general methodologies dealing with functions or reasoning about functions, at present time, satisfying solution to both issues has not yet arrived.

Aiming at solving some crucial issues discussed above, this paper constructs a functional design process model for function modeling and function-to-structure mapping, which is based on multi-pole effect model, effect chain modes and combined rules of principle structure.
2. Effect

Effect is one of the knowledge base tools in TRIZ. By the analysis of hundreds of thousands of patents, effects are emerged from the relevance between functions delivered by a design product described in a patent and a principle used in the product.

An Effects is an input and output relationship that combines the laws of science including physics, mathematics, chemistry and geometry, and their corresponding engineering applications, which helps to bridge the gap between science and engineering and is good for generating solutions of high levels.

However, few literatures on effect exist in TRIZ monographs and few researches on effect exist in international, for example, only the concept, sort and use of effect are introduced in literature. There is no literature on functional design based on effect.
2. Effect

An effect has an input and output flow, which is called as basic effect, thus the effect model has two poles, as shown in Figure 1(a).

The two-pole effect model is extended in this paper. Most transitions from input to output with effect are controlled by auxiliary flow, so the controllable effect should be denoted with three poles, as shown in Figure 1(b).

The control flow specifies the factors that can be manipulated to change the output intensity of an effect. Generally speaking, an effect may have multiple input flows, output flows or control flows, so the effect has multiple input poles, output poles or control poles, as shown in Figure 1(c).
2. Effect

The effects need to be linked sequentially into chains through their input, output or control ports and compatibility of adjacent effects. Effect modes are the basic coupling manners of effect chains, as shown in the following:

(a) Serial effect mode

(b) Parallel effect mode

(c) Ring effect mode

(d) Control effect mode
3. Function

Function is a statement to describe the transformation between inputs and outputs, aiming to achieve the designer’s purpose.

Function is expressed as noun-verb-noun, which is different from the accustomed expression of verb-noun.

Subsuming all other classification schemes discussed above, the 30 functions in TRIZ are expanded and reclassified and the standard set of functions is presented, which includes a behavior (verb) set and a flow (noun) set.

Products are defined by the overall functions. The overall function can be broken down into several sub-functions. The aggregation of functions and their relations is called function model.
4. Structure

Structure is a physical embodiment of effect and the change of structure from one state to another must be caused directly or indirectly by effects.

By means of patent analysis, the structures, which show how the effect is used for the performance of function transitions, can be acquired.

A structure contains structural feature, such as what elements the design is composed of, what the attributes of the elements are and how they are related.

An effect can have varied realizing structure, and a structure can be used for varied effects.
5. Functional Design Based on Effect

The process of functional design can be seen as transforming a functional representation to a design description or physical representation through function, effect and Structure.
6. Case Study

Pill is a kind of good form of Chinese traditional medicine, but it can not be produced by Western medicine facility for its process and physics characteristic. The present condition is long process, high energy consume and great labor intension, so it is important to develop continue forming and shorten process to meet the need of modern times.

The granulator system can be initially modeled as a black-box, whose inputs are powder (medicinal powder) and liquid (cementing liquid), and whose outputs are sphericity and particle (pill).
6. Case Study

According to the known inputs and outputs, search for the effects in effect database of E2F Design software. The effects can be automatically linked into effect chains by using effect modes. Figure 7 shows the part of effect chains of granulator system, which are mainly based on fluidized bed effect, vibration effect, plastic deformation effect, shear effect, friction effect and electromagnetism effect.
7. Conclusion

This paper proposes a product functional design approach based on effect by the followings:

- **The multi-pole effect model and effect modes for effect chain are created to extend effect in TRIZ;**
- **The functions and flows in TRIZ are reclassified and the standard function set is presented;**
- **The combinative relationships among functions are discussed and the function modeling based on effect is proposed;**
- **The functional design process model for function modeling and function-to-structure mapping is proposed, and the computer-aided functional design software is developed.**
- **A design example for conceptual design of air exhaust valve in car is presented to demonstrate the proposed functional design process and prove that the method is feasible.**
Biography of Author

• Cao Guozhong is a lecturer in the School of Mechanical Engineering, Hebei University of Technology, PR China. He received his PhD degree in 2007 and MS degree in 2003. His research interests are in innovative design, CAD, etc.
Thanks!