http://dx.doi.org/10.5392/JKCA.2011.11.12.690

그린 디자인의 DFX법을 도입한 시계 디자인 연구

Study of Clock Design Applied to DFX Methodology of Green Design

염청, 고경욱
동서대학교 디자인학과

Yan Qing(audrey8171@hotmail.com), Kyeong-Uk Koh(kkw@dongseo.ac.kr)

요약

현재 그린 디자인은 제품 디자인 분야에서 대부분 개념적으로 거론되고 있다. 디자이너와 제조사는 환경 문제에 대한 관심이 부족하고, 디자이너는 그린 디자인에 대한 명확한 원칙적인 이론 기초가 부족하다. 이 때문에 그린 디자인의 방법과 과정 연구는 매우 절실하다. 본 연구에서는 DFX (Design for “X”)방법은 우수한 디자인을 창출하기 위해 원칙적인 방법이라고 설명한다. “x”는 여러 가지 창조성 가치를 의미한다. 이를 근거로서 본 연구에 DFMs, DFR, DFA, DFD의 원칙을 방향으로 시계 제품 시장 중에 어떤 제품을 그린디자인 개념을 유지한다는 것과 긍정적 표현을 설명한다. 본문은 현제 시장에 시계 제품의 중류를 대표할 수 있는 30개 제품을 샘플으로 선정하여 DFX의 원칙을 기반으로 평가를 하였다. Framework을 이용하여 평가결과에 따라 그린 디자인 원칙을 가장 맞추지 않은 원료문제를 중심으로DFMs 원칙들을 지침으로 실험을 전개한다. 그린 디자인 기본 개념보다 DFMs방법을 도입하여 실험과정에서는 핵심요점을 더욱 쉽게 파악할 수 있고 최종 원성 결과물을 통한 DFX방법의 중요성을 간접적인 설명하게 된다.

■ 중심어 : | DFX방법 | 그린 디자인 | 시계 디자인 | 3R |

Abstract

Green Design is mostly discussed in the field of industry design on the concept basis, while less attention to environmental issues have been paid by neither designer nor manufacturer, which thereby adds to the necessity of the study on Green Design methods and process to a great extent. This article through the classification and analysis of DFX, researches on which kinds of designs in the Clock products market are invested with green design concept as piloted by the principle of DFMs, DFR, DFA and DFD. DFX means design for excellence, and also ″design for X″, where X is a variable with many values. Under the label Design for X, a wide collection of specific design guidelines are summarized. This article conducts DFX principle assessments on Clock by selecting 30 products of Clock market varieties as the samples, and conducts the field design practices centering on those materials of the least conformity with green design tenet amidst the Framework assessment results. In the course of field practices, DFMs principle is introduced, and embodies the significance of DFX method guidance by virtue of the ultimate results of conceptual designs conducted in the guidance of theoretical basis.

■ keyword : | DFX(Design for 'X') Methodology | Green Design | Clock Design | 3R |

접수번호 : #110930-003
접수일자 : 2011년 09월 30일
심사완료일 : 2011년 12월 05일
교신저자 : 염청, e-mail : audrey8171@hotmail.com

1. Design Background and Objectives

The recent studies showed that, environmental problem is not isolated, but links fundamentally with the issue of resources and population. Therefore, a new concept emerges recently: the key to environmental problem lies in the effective utilization of resources with minimum wastes. While the optimal utilization of resources and minimum generation of wastes all point to one way－Green Design and Green Manufacturing. Meanwhile, designers shall integrate environmental awareness into design, so as to enable the favorable environmental development of the product in terms of materials structure.

Under the background premise above referred to and with Clock as the practice object, conceptual design is conducted under the objective of green design. In order to perform the design in a reasonable and smooth manner, the article, first of all, centering on the most active DFX method in the realm of green design, has comprehensive researches and summarization on its concept, content and the corresponding principles. Secondly, through surveys on the Clock market, the article has gathered together flow-blown product samples and developed Framework to conduct evaluations on the samples using DFX principles as the criteria. The derived results are that, the clock samples are far from the principle requirements of DFMS. In other words, the samples do not conform to the standard requirements of green design respecting material selection. Therefore, in this essay, as the sample's analytical results, we re-designed the clock focusing on the existing shortages as DFMs (Design for Materials) principles based on the original intension of GD promotion. One of the ultimate purposes of the article is, on the basis of sorting and understanding the basic methods and applications of DFX, to have in-depth extension of its applications in Clock, and translate DFX theoretic principles into practices, so as to make the Clock's conceptual design well-founded. The second, on the basis of practice activities, it enables to experience and affirm that with introduction of DFX method, the design develops an even rationality than the conventional conceptual designs, making an even simple and concise design flow, and the design result even reasonable.

2. Green Design Theory

Green Design(GD), or Ecological Design(ED), Design for Environment (DFE), Life Cycle Design (LCD), etc. its connotation and basic idea lie in including environmental factors and preventive actions against pollution into product design, so as to minimum the environmental influence of products by regarding environmental factors as the objective and basis of design. The knowledge points pertinent to green design include mainly the following[1].

① Green design is detachable and resolvable product devised on the basis of the nucleus concept "environment and environmental protection", and its spare parts can be reutilized after being renovated;

② An article in an American biweekly periodical "Felicity" in February 1995 considered that green design is those products that purport to reduce number of parts, and utilize reasonably raw materials, and can be safely disposed;

③ Green design is the products that meet specific environmental requirements in the whole course from production, use and recovery, less hazardous to ecological environment, and can be regenerated or recycled for use.

Therefore, Green Design can be defined as: during the full course of product's life cycle, taking the environmental properties (i.e. utilization of natural

resources, detachability, recoverability and recyclability, etc.) of the product as a focus and design objective, where the environmental requirement is satisfied, the basic function, service life, etc shall also be taken into consideration[2].

3. DFX Method

3.1 DFX(Design for 'X') Concept

Currently, among the green design measures, the most active one is of DFX pertinent field. DFx (in Engineering), refers to Design For all desirable attributes: Design for manufacturability; Design for assembly; Design for test; Design for X.

"Design for X," also means design for excellence, "X" adverted to include multiple contents as Assembly, Recycle, Service, Environment, Disassembly, Material, etc. Under the label Design for X, a wide collection of specific design principles are summarized. Each design principle addresses a particular issue that is caused by, or affects the characteristics of a product. The design principles themselves usually propose an approach and corresponding methods that may help to generate and apply technical knowledge in order to control, improve, or even to invent particular characteristics of a product.

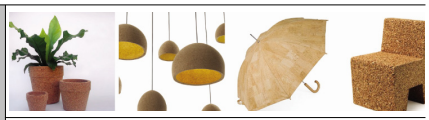
3.2 DFX(Design for 'X') Specific Principles

This essay studies the contents of DFX, and classifies its design principles from the following aspects.

3.2.1 DFMs(Design for Materials)

DFMs refers to that the green materials with low energy consumption, less polluting and easy for recycling, reuse or degradation after scrapping shall take priority over other materials during the selection by designers[3].

Table 1. Products with green materials

DFMs principles
① Less use or no use of hazardous or poisonous materials as far as possible. ② Preference over recyclable or reusable materials. ③ Preference over materials easy for processing or of pollution-free. ④ Less use of materials of shortage, preference over waste, excess and recycled materials as the raw materials. ⑤ Minimize the materials types for products ⑥ Adding no surface treatment; ⑦ Low energy consumption, low cost and less pollution; ⑧ Easy to recycle, easy to dispose, reusable and degradable.
Cork

Cork is an impermeable, buoyant material, a prime-subset of bark tissue that is harvested for commercial use primarily from Quercus suber (the Cork Oak), Cork is composed of suberin, a hydrophobic substance, and because of its impermeability, buoyancy,
Corrugated fiberboard

Corrugated fiberboard is a paper-based material consisting of a fluted corrugated sheet and one or two flat linerboards.
Bamboo

There are a lot of bamboo products on the market these days. As said in yesterday's post bamboo is a great alternative to wood as it grows very quickly and is more eco friendly than timber. Asus' Ecobook (above) is covered in bamboo. And of the plastic used for this laptop is labeled and recyclable; it is lined with cardboard; there are no paints, sprays or even electroplating used on its components. Not only environmental friendly but gorgeous looking as well!
Corn Plastic

Until recently, plastic products have been manufactured utilizing a petroleum based material. Now, there is a natural plastic – made from USA Corn. These corn based products have the durability of plastic, but break down naturally by composting. That makes them good for the environment and good for American industry.

3.2.2. DFR (Design for Recycling)

In terms of product design, the core of Green Design is "3R" (namely Reduce, Recycle, Reuse), which demands to possibly reduce the consumption of materials and resources, and the discharge of hazardous materials, while enabling the recycling and reuse of products and parts. To sum up from the concept and directions of Green Design, we shall be more responsible in producing more forms of products, so as to prolong the service life of products with concise and lasting design, or enable recycling and reusing[4].

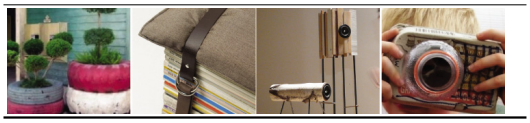
Reduce	buy less and use less
Reuse	elements of the discarded item are used again
Recycle	discards are separated into materials that may be incorporated into new products. This is different from Reuse in that energy is used to change the physical properties of the material

The 3R's of reduce, reuse and recycle have been considered to be a base of environmental awareness and a way of promoting ecological balance through conscious behaviour and choices. It is generally accepted that these patterns of behaviour and consumer choices will lead to savings in materials and energy which will benefit the environment.

Design for Recycling refers to a design method which takes the possibility and methods of material recycling into full consideration in design, so as to save materials, eliminating waste and minimize pollution.

Table 2. Products for DFR

DFR(Design for Recycling) principles
① The structure is easy to remove
② The classification of reusable parts is easy to recognize
③ The structure design is easy for adjustment or maintenance
④ Frequent use of recycled parts



3.2.3. DFA & DFD

1) DFA(Design for Assembly)

The consideration for assembling design lies in the soonest assembling certain product, while ensuring its final assembling quality. In a broad sense, DFA(Design for Assembly) indicates to conduct quantitative analysis on the assembly of products in the early stage of product design, to optimize design while reducing assembly time[5]. There are some basic principles for DFA. Generally, you want to start with a concept design and then go through each of these principles, decide whether or not it is applicable, and the modify the concept to satisfy the principle. There is no guarantee that a given principles will apply to a particular design problem.

2) DFD(Design for Disassembly)

To credit a product with good disassembling performance, it is necessary, early at the conceptual design period of such product, to give full consideration to the disassembling difficulty, namely, to have disassembly design. The major role of DFD design is the duality exhibited in the aspect of product maintenance and recycling. In the aspect of maintenance, product disassembly must be handled with care, in order to reassemble; In the course of product recycling, the way of disassembling tends generally to be destructive, so as to achieve the purpose of part decomposition. Design guideline of DFA and DFD is as the below table:

Table 3. Products for DFA

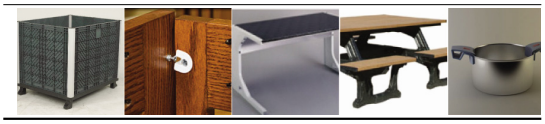
DFA(Design for Assembly) principles
① Parts minimization ② Assemble all parts in the same direction ③ Assemble parts possibly within visible scope ④ Assembling is performed externally, and assembled parts are easy to recognize ⑤ Reduce the use of fasteners such as bolt, etc. ⑥ Part is characterized by interlocking convex and concave


Table 4. Products for DFD

DFD(Design for Disassembly) principles
① Combine the parts of similar functional structure ② Reserve handling points on the surface of parts. ③ Good material compatibility, capable of together recycling, so as to reduce the work load of classifying disassembly. ④ Simple part connection, to reduce the number of fasteners used.


4. Clock Analysis Based on DFX

4.1 Clock for DFMs(Design for Materials)

Green materials refer to environmental safety materials that are not hazardous to human health during production and application, nor cause any environmental pollution. The product passed the quality certification of Green Design is energy saving and environmental protection, which demands to save the unsustainable materials while improving the utilization rate and recycling rate of materials[6].

Table 5. Corrugated fiberboard and cork clock

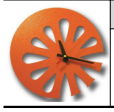
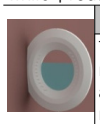
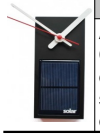
Corrugated fiberboard and cork
Corrugated fiberboard and cork are reusable and easy for degradation, with little waste generated during manufacturing, which therefore play an irreplaceable role in the environmental protection on the earth.
Laser Cut Corrugated Card Clocks, by The Rise Set[7]
 Victorian fretwork inspired clocks cut from corrugated cardboard. Designed and made by Jonathan Sturgess of 'The Rise Set'
Alarm Clock Saves Materials By Coming Packaged in Its Own Casing[8]
 This alarm clock is an exercise in efficiency, using the box that it comes packaged in as a casing once you get it home. Made of corrugated cardboard, it would be able to be taken apart and then put back together with a space for the actual clock component.
Changzhou Huapu Cork Products Co. Ltd. cork clock
 clock is made of portugal cork,green product,round shape,can be hanged against wall as wall clock,very nice,so can be decarative house product,dia is 22cm,customized size is also vibale for us to produce
Juice Clock
 The Juice Clock is created from recycled corn plastic. Availabe in orange, lemon or grapefruit and bursting with great taste.

Table 6. Clock with Energy and water

Energy and water efficiencies clock for reduce
The energy and water consumption during utilization of products may produce a large amount of pollutants. Therefore, it is a demanding issue for the application of energy with minimum environmental inference to the design, while producing maximum effects of products.
Aqualicious Clock[9]
 The Aqua Clock is designed to show time in a new way. A mechanism inside moves the water up and down and apparently water is the perfect non-resistant element.
Sun & Solar Powered Clock
 Light Gap is a concept clock with solars cells on its backside. You stick it on a window so sunlight can illuminate the slit on the face to form the hour hand.
Bedol Eco-friendly Clock Powered by Water
 The Bedol clock is the first clock powered by water.
Solar-powered Clock
 A clock that is powered by the sun, the Solar Clock is a handly little clock that will never run out of power. This fantastic device will absorb sunlight through the solar panel attached and will even continue to run at night

4.2 Clock for DFR (Design for Recycling)

Table 7. Clock for recycling

Clock for Recycling
Recycled clock -one weird way of going green[10]
 Clock made from recycled materials. Green products aren' t necessarily eye-striking and wonderful. The products get to go crazy mostly when they are made from recycled materials. Check out this clock made from a recycled PCB with an old and broken CD serving as the dial.

	Resource Revival Sprocket Wall Clock[11]
	Resource Revival's Sprocket Wall Clock is made from a recycled bicycle chain ring with a printed paper face. Powered by one included AA battery.

The recycling of products had an important place in the life cycle engineering of Green Design. Through various means of recycling strategies, the product life cycle will form an enclosed circuit. The end-of-life product will enter into next life cycle. Therefore, recycling is rather important for realization of Green Design.

4.3 Clock for DFA & DFD

Table 8. Clock for DFA & DFD

Clock for DFA & DFD	
Clock Design for Assembly	
"GRAND FATHER CLOCK by Giles Miller" Double wave cardboard floor clock. Easy to assemble.	
Clock Design for Disassembly	
The Clock becomes a piece that can easily be taken out of the housing for travel. Clock Design for Disassembly Made for items to be easily taken apart by consumer for convenience in recyclable waste stream.	

Assembling and disassembling are two mutually antithetic aspects in product's structural design. A structure easy for assembling is not necessarily easy for disassembling, and vice versa, disassembling is not definitely a reverse process of assembling. Therefore, how to vest product structure with good assembling performance, while enable it to be disassembled in perceived process is what has to be solved in the design of green product.

4.4 Marketing analysis for framework

Through the above analysis on various cases, we can easily see the extensive application of Green Design concept in clock design. And principle items as specified by DFMs, DFR, DFA and DFD will be provided below to benchmarking the product, and henceforth find out the shortcoming and improving points of the product.

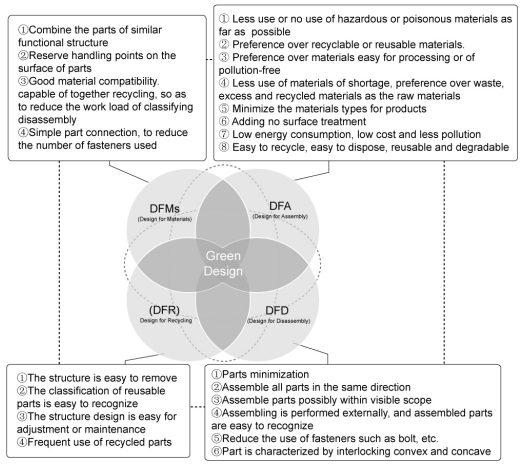


Fig 1. Principle items as specified by DFX method

The essay selected thirty types of representative clock design to evaluate each principle items of DFMs, DFR, DFA and DFD. These clock samples cover basically all types of clocks in the market. The surveys conducted by selecting the samples enable certain understanding on the materials, construction and surface treatment, and function, etc. These samples are displayed in form of Imageboard after arranging in the order of G1-G30. The samples which were used to evaluate are selected from two directions, the first direction is selected by the network contains a certain number of conceptual design products which contain element of design modeling, and has not been circulating in the market, the second direction is selected by the network a number of products sold in the market now in circulation.

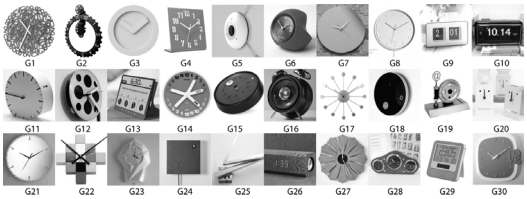


Fig 2. Samples image board of clock marketing

[Fig 3] is the framework designed for evaluation on the 30 clock samples, in which, the horizontal axis is arranged with DFMs principles, DFR principles, DFA principles and DFD principles derived from DFX method in the text research, while the vertical axis is list of clock samples No 1~ No 30. In the Framework, "+" is used to represent whether each sample complies with the principles of DFX.

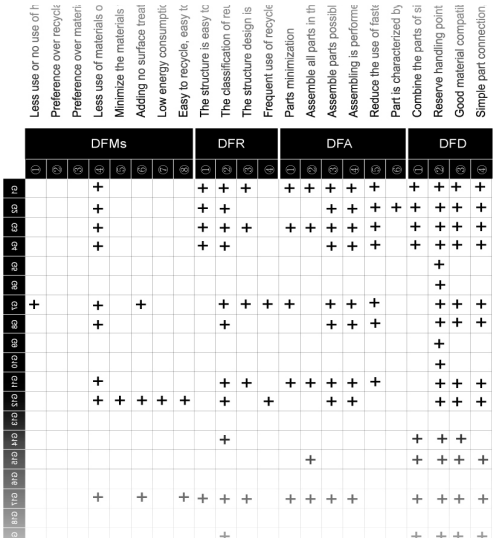


Fig 3. Value point framework for DFX principles

By the final statistical analysis, the derived results are that, the clock samples are far from the principle requirements of DFMs, not coming up to the standards as required by DFMs. In other words, the samples do not conform to the standard requirements of green design respecting material selection. At present, most clock designs in the market are complicated in function, the plastic or PVC material may reduce the cost, but is in lacking of security and bad for recycling or reuse; the amusing feature adds no good to the applicability.

With the development of Green Design, there are an increasing number of designers attaching importance to environmental issues. Seen from the Framework analysis, many designs, though perfect in respect of recycling, assembly and disassembly, meet the overall criteria basically. This further indicates the weakness of material selection. Great attention shall be also paid to clock products in DFMs (Design for Materials) principles, so as to cover the shortage in material. Therefore, in this essay, on the basis of the understanding of the theory and case of DFX method, and as per the sample's analytical results, we re-designed the clock focusing on the existing shortages as DFMs (Design for Materials) principles based on the original intension of Green Design promotion.

5. Design Experimentation for DFMs Items

5.1 Research and Material set up

There are many wastes around us every day, Green Design advocates to reuse those materials appropriately before discharging, so as to minimize degradation. The objective of re-design is to use eco-materials and recycled materials as many as possible in design and production. Based on the design concept of safety and pollution-free, the materials defined in this article include the following: discarded carton without painting, original kraft paper, discarded fur, etc., the adhesive used in the process is made of rice paste.

Fig 4. Green-materials for clock

Carton and wood pulp paper belong to recycled materials, which are flexible, degradable and easy to bond. The reuse of discarded fur minimizes environmental pollution due to degradation. The application of those materials reflects the concept of "primitiveness", and sheds light on the principle items of DFMs.

5.2 Methods and procedures

5.2.1 Option one

The design focuses on the application of two single materials to pursue the superiority of materials selection, simple process and usage, attractive appearance, and diversity of choice, etc. Two options are provided below.

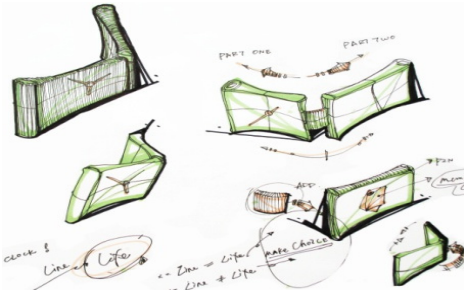


Fig 5. Idea sketch of option one

Wind the man-made paper string around the paperboard made of carton, a sense of primitive joy may arise from each round. The softness of paper also enhances its flexibility. Detailed process is shown below.

Fig 6. Production process of option one

① Twist the paper strips into strings

② Cut to carton into basic formation; apply rice paste to the carton

③ Wrap the strings around the carton

④ The option one develop into two types of route as follow:

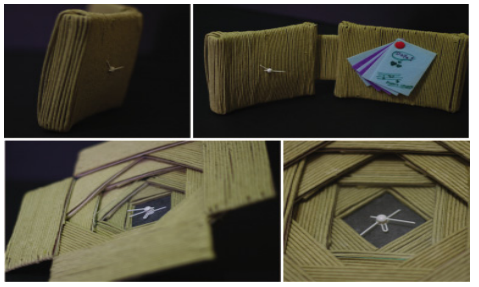


Fig 7. Final works of option one

5.2.2. Option two

Option two: reuse the discarded fur, in order to achieve the visibility and sensational satisfaction, one shall follow the tenet—"concise but pretty, small but delicate" all the way from design idea to production.

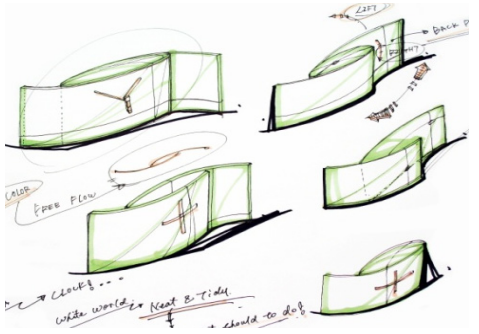


Fig 8. Idea sketch of option two

Fig 9. Production process of option two

Option two seems simpler by neglecting the procedure of making strings. The principle of subtraction in design is provided by curving or extending to enable the better performance of white PU. A second idea arose by curving leftover materials into cigarette butts, forming a radiation formation by inserting or overlaying, which reflects the concept of environmental protection and health unconsciously.

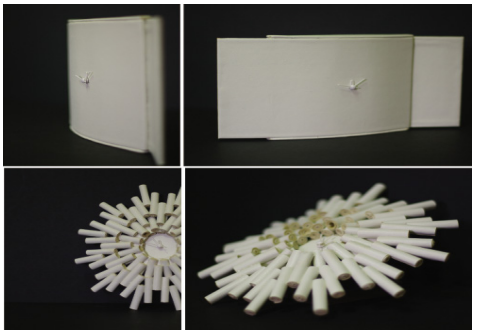


Fig 10. Final works of option two

6. Conclusion

Green Design has an omni-directional coverage, with certain theoretical basis and guideline in each direction, and their objectives however, are consistent. That is to say, green design in whatever field, is, as guided by certain design method, to make the final result of design to conform to the criteria of green design. Starting with DFX method, the article summarizes design principles and theories in the four directions: material, recycling, assembly and disassembly, find out the underpinnings for clock redesign of green conformance, before making substantial through practice activities. That is to say, the clock design practices are performed under specific and directional green design approach, other than blind and random exertion subjecting to no method restriction. Compared with design conducted under pure green design theory, the clock design unfolded under each principle of DFMs is even easier to find a breakthrough, the design process is even fluent and smooth, and the design results are vested with even good credibility. The clock practices proves even profoundly the application of green design under the guidance of DFX method is reliable and necessary. Therefore, under the backdrop green design is such a popular advocacy, it is not only necessary to have design in reliance on existing methods, but also to develop more and better methods to popularize green design, which is a potential and subsequent research task.

참 고 문 헌

[1] Y. C. Wang, Green Design Product Concept and Implementation Strategy, Modern Machinery, Vol.1, pp.5-8, 1999.

[2] M. L Yang, K. Z. Cai, The Future Direction of Industry Design-Green Design, Packaging Engineering, Vol.22, No.3, p.24, 2001.

[3] J. G. Lin, Green Design Method based on Principle, Journal or Machine Design, No.9, p.5, 2001.

[4] J. F. Li, Present Status and Prospects of Green Product Design-DFX Methodology, Vol.11, p.61, 2004.

[5] G. F. Liu, *Green Design and Green Manufacture*. China Machine Press, 2000.

[6] C. H Li, Industrial Design Starting from "Green Design," Modern art and design, Vol.131, p.69, 2004.

[7] http://www.materialicious.com

[8] http://ecojotter.blogspot.com

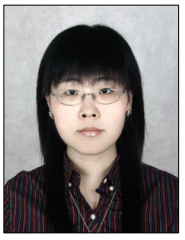
[9] http://www.yankodesign.com

[10] http://www.ecofriend.com

[11] http://www.coolstuffcheap.com/26p.html

저 자 소 개

염 청(Yan Qing) 정회원



- 2004년 7월 : 중국 전진 과학 기술 대학교(프로덕트 디자인)
- 2009년 1월 : 한국 동서대학교 디자인학과(디자인석사)
- 2009년 3월 ~ 현재 : 한국 동서대학교 산업디자인 박사과정 수료

<관심분야> : 디자인 연구와 응용

고 경 욱(Kyeong-Uk Koh) 정회원

- 1985년 8월 : 홍익대학교 산업디자인학과
- 1994년 2월 : 홍익대학교 산미대학원 제품디자인 전공.
- 2004년 2월 : 부경대학교 산업디자인 박사수료

<관심분야> : 친환경 디자인