LEAN ENGINEERING THROUGH APPLICATION OF VE TECHNIQUES

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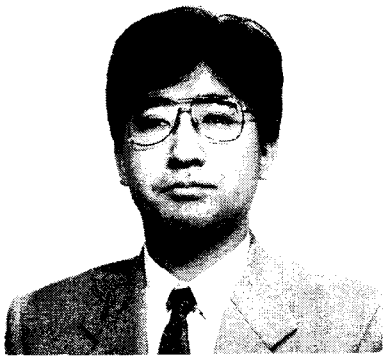

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ABSTRACT

This paper introduces a technique to design Effective New Product Development Process (ENDP) to be based on VE-centered thinking and some effective Functional Analysis techniques to help companies utilize this ENDP approach. This should enable customers to be provided with high valued products and at the same time help producers realize Lean Engineering by way of eliminating unnecessary burden, unevenness in work and wastefulness in resources largely through the product engineering and engineering phases. Also proposed in this paper is a method of quantitatively estimating the effectiveness of Lean Engineering from VE point-of-view.

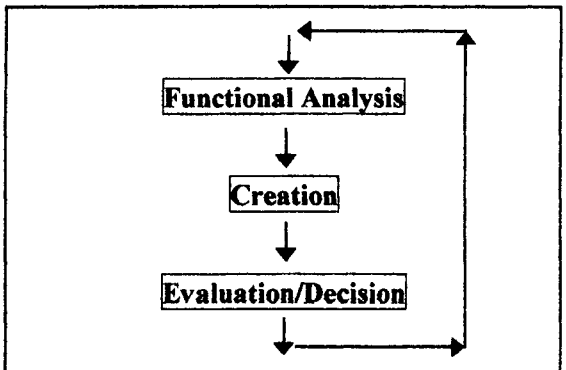
1. INTRODUCTION

This paper will propose a new integrated product development system (called Lean Engineering System) that can provide quality products (Q) with good price (P) in a timely manner (T) to customers by combining the problem-solving process of VE with the development process of new products. It will touch upon later devices and applications of VE techniques (centered upon functional analysis) that are required for implementing Lean Engineering more effectively. Lastly it will propose as an attempt a method to understand quantitatively a degree of effectiveness of implemented Lean Engineering in terms of VE.

2. HARMONIZATION OF NEW PRODUCT DEVELOPMENT PROCESS AND VEP

2.1 VEP as gist of developmental design process

Because the work flow of the new product developmental process cannot be understood as a phenomenon as opposed to that of the manufacturing process, there are many companies that cannot dare involve themselves in the activity process management. Consequently this issue is frequently sidestepped with an opinion that since development is a creative task, it does not match with management. Management of activity process, however, does not infringe upon creation. Rather it is essential for accurate understanding of customers' demand (Q, P, T) and for concentrating creativity. It is important to cope with acceleration of technological innovation nowadays. The process of developmental design itself must be standardized and entire flow should be specified to implement process management. The main point of standardization is VE in terms of "reasonable design process," and the VE in a strata form is the VE job plan by stage (corresponding to 0 Look VE/1st Look VE/2nd Look VE). Chart 1 describes a flow of problem-solving process of VE.



Reasonable design process
= repeating problem-solving process of VE

Chart 1:VEP Flow

In actuality, the design output will be sophisticated by repeating the process in the actual developmental design activity. By implementing a design review (hereafter called DR) in a timely manner throughout the process, quality products will be materialized.

2.2 DR and new product development project

DR means, "design review to actualize products with a high customer satisfaction." Its essential purpose is also to obtain constructive proposals, advice and cooperation for design output from non-technical departments (such as production engineering, manufacturing, quality control, materials, and operations). DR, therefore, must have become an activity that encompasses the organization of the entire company to effectively deal with problems of product development before the products are completed. Accordingly, DR activity plays an important role to actualize products with a high customer satisfaction as well as to eliminate overburden (muri), waste (mura) and unevenness (muda) in developmental design activity itself.

To maximize effects of the above stated DR activities, the planning and development departments must not deal with development of new products exclusively. The essential system to realize products with a high customer satisfaction is to develop new products under the TFP (task force project) method and simultaneously implement DR activities.

2.3 Design of customer-oriented new product development process at Company A

The author will state a case where the above-mentioned new product development process with a high customer satisfaction was applied to a "new product development operation

of the circulation type small rice dryer, a product of an agricultural machinery manufacturer that the author actually instructed. In this company, such development activities of new products were largely shouldered by the Development Design Department. DR activities were dealt at the "Production Transfer Meeting." Accordingly, many problems that required an extensive design change frequently appeared after completion of trial product. Consequently, merchandizing could not be completed by the marketing period and was constantly postponed extensively to the next business year.

For Company A to outrun chasing competitors that were aggressively introducing new products to the market in recent years, it was planned to materialize high-quality products within originally scheduled development period by designing a new product development process with a high customer satisfaction as a specific standard of Company A and by implementing its process management.

Thus, VE was linked to the development process of new product. Team members could easily participate in development steps (corresponding to VE job plan). They could deal with VE techniques without a sense of incongruity.

3. CONCURRENT ENGINEERING IN NEW PRODUCT DEVELOPMENT

3.1 Summary of concurrent engineering effect

Although the process experienced a little delay during activities, DRs were effectively implemented in relevant points of activities. Therefore, no problems occurred concerning design changes after production transfer that had been frequently seen in traditional development cases, and the new product was completed in 15 months, not far behind the original plan. In this case, it can be stated that the effect of concurrent engineering was demonstrated.

3.2 Effect on lead-time reduction

In conventional product development, a scheduled development period was hardly sufficient for product manufacturing, and it took more than 1.5 times longer in average. In this case the product development was completed in about 15 months as was scheduled, which means that reduction of lead-time for about 40% was practically actualized.

In addition to the effect of designing the standard development process of new product in advance to activities, there were factors in the activities that had contributed to reduction in lead-time. These factors can be divided into the following three categories.

(1) Effect of TFP method

Beginning with this new product development, development operations were positioned as a formal project activity. In addition to engineers, related people could directly participate in product development activities from the planning stage. Therefore, activities could be conducted in a rugby-type scrum method rather than a serial method. Communications between the technical division and other divisions were improved so that lead-time was shortened. Points that were particularly effective in the first half of activities (planning stage) were that conflicts between sales and technical divisions were avoided. In the latter half of activities (mass production preparation stage), good communications between manufacturing and technical divisions were actualized.

(2) Effect generated from DR implementation

DR was effectively employed for activities of this case. DR was implemented for about 6 times from the planning stage to before product shipment. Every DR is connected with the progress of VE. Participants of DR (department managers of each division) could accurately understand the substance of project activities (each VE step). Discussions between project members and participants could be realized.

Through DR, it became possible to obtain positive proposals and advice in a timely manner. Cases of criticism against and demands for the technical division expressed afterwards was radically decreased accordingly, which greatly contributed to reduction in lead-time. What also seemed to have contributed greatly was that each head of the divisions that had sent their staff as project members tried their utmost to maintain communications with members in advance.

Because president as well as heads of each division attended all DRs, interest among employees in activities of the case was sufficiently elevated, and team members became highly motivated. That development of new product is a task to be shared by every division and not exclusive to the technical division was understood by one after another starting from the top management. That was the reason why concurrent engineering was highly effective.

(3) Effect of utilizing in-house e-mail system

Company A had already introduced an in-house e-mail system to the management (to section chiefs equivalent and above). Therefore, attempts were made to send important items (especially prior information concerning DR meetings) of this case real time to the related managers through e-mail. Consequently, it became possible to have participating members completely informed of issues for discussion prior to DR meetings. Blessed with such effects, it was not required to set aside extra time for introductory explanation on the day of a DR meeting, and members could immediately take up main agenda. The in-house e-mail system has been quite effective in reducing lead-time.

3.3 Effects on quality and cost guarantee of new product

In this case, new products with guaranteed quality and cost were manufactured (hereafter called new model A1 type). In VE-oriented expressions, it was intended to manufacture new products with high value. Except for a fixed engineering part, It can be considered that VE techniques (specifically functional analysis-related ones) that played a role of foundation for new product development seemed to have contributed quite extensively in actualizing new products of high value (new products with guaranteed quality and cost).

It is impossible to state every VE technique utilized in this case, but the author will touch upon the points which were devised by him in the following chapter.

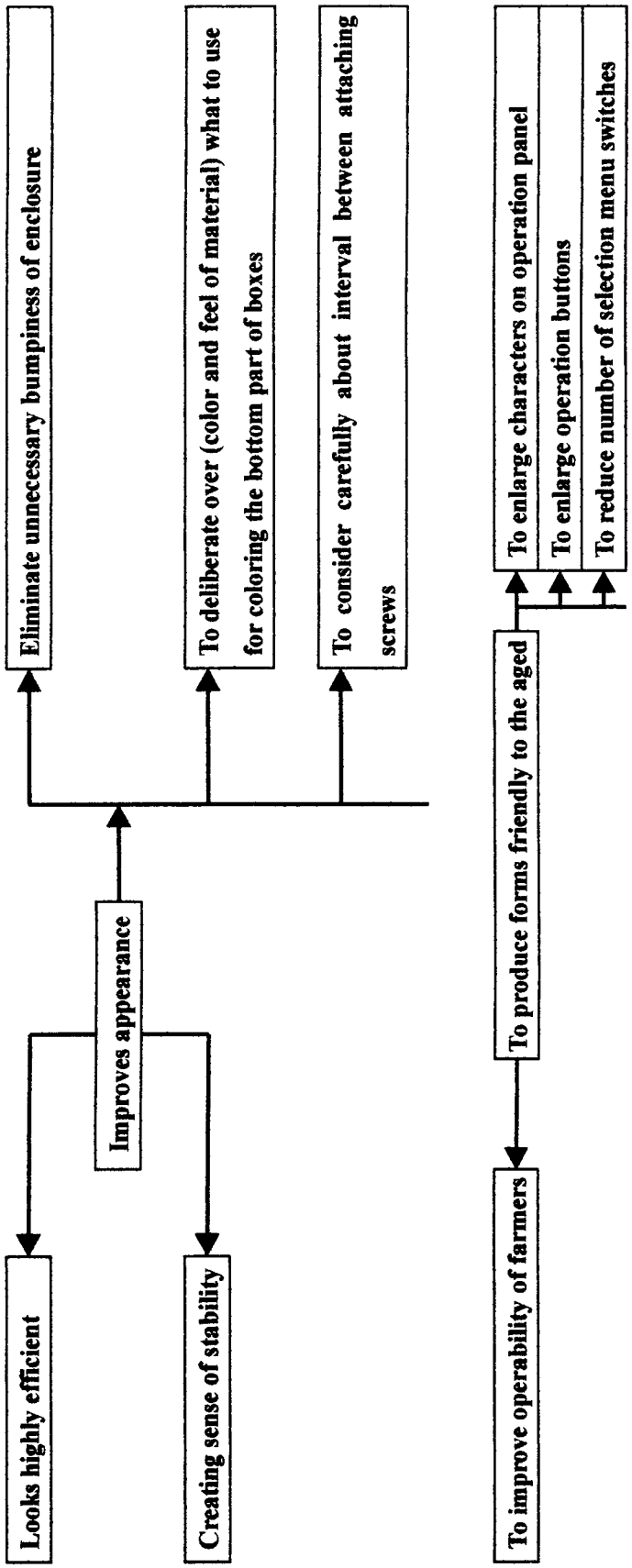
4. MAJOR VE METHODS USEFUL FOR CONCURRENT ENGINEERING

4.1 Functional analysis employing QFD (quality functional development) viewpoints

In VE activities at the planning stage, the important thing is to specify functions required by customers and to convert the functions into design quality (technical specifications) so that such functions can be perfectly realized. As a concrete technique, the technique of functional analysis

Customer satisfaction factor	Basic function		Credibility		Economy		Operability		Mainte-nance		Safety		Installation		Amenity		Taste		Resilience
Design quality item / Item required by customer / Frequency	Dust removal capacity ○○	Holding capacity ○○	Heat conduction		Fuel efficiency ○○		Easy operation panel		Streamlined wiring		Enclosure strength ○		Concern for installation site		Reduction in ventilator sound ○		Design		Manual possible operation
To remove dust from unhulled rice A	◎ 5																		
To lower sound of ventilator A															◎ 5				
To expand holding per time B		○ 3																	
Installation at front & back of elevator A													◎ 5						
Form friendly to the aged C																	○ 2		
Number of point for each satisfaction factor(total points of 335)	48		35		13		35		42		37		53		35		17		20
Degree of influence of each satisfaction factor point = each satisfaction factor divided by total points	14.3%		10.4%		3.9%		10.4%		12.5%		11.0%		15.8%		10.45%		5.1%		6.0%

Chart 2: Development Chart of Items Required by Customers × Design Quality Items



← To clearly state reasons why certain attractive functions are necessary

→ To clearly state means to achieve certain attractive functions

These were actually considered at the design stage and were actualized

Chart 3: Systematic Chart to Understand Facts about Attractive Functions

based on QFD has been utilized in this case. In the worksheet in Chart 2, relationships between items required by customers (results obtained from the survey on development products conducted simultaneously by nationwide sales offices) and each of customer satisfaction factors was clearly stated. Also shown are part of results where design quality items to be actualized in new products were extracted from customer satisfaction factors.

If design quality items that are directly linked to customer satisfaction can be clearly established at the planning stage by utilizing the above techniques, no trial and error will be required at the following developmental design stage. It will not only guarantee product quality, but will also contribute to reduce lead-time in consequence. To use such techniques effectively, however, a precondition must exist where a standard process of new product development is established and the process management is working well.

4.2 Preparing facts understanding system chart of attractive functions

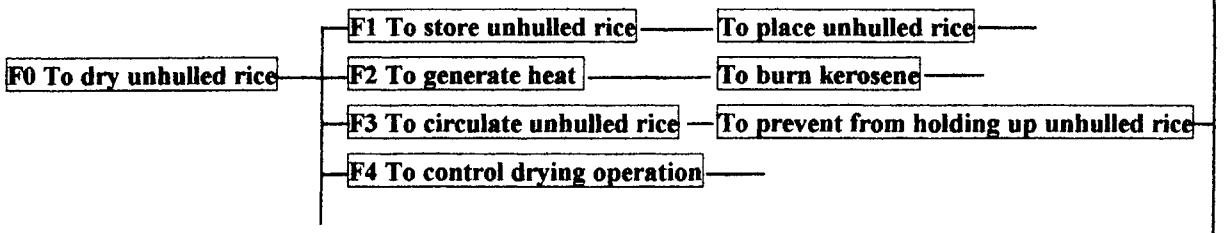
Attractive functions belong to an arena of sensitivity and are closely related to three elements of design (color, form and feel of material). The author calls the attractive functions as art design functions. To describe such functions with the above characteristics in such an expression as "to maintain beautiful appearance" and include them in the useful function system chart for convenience is not sufficient to understand the facts, except for part of production goods. In this case, however, the author adopted a method to understand the facts about attractive functions that systematized the attractive functions as logical as possible while answering several questions (systematic chart to understand facts about attractive functions). This method contains a technique adjusted to VE by the author, while also making reference to the Laddering method, a technique to assess design environment. Shown in Chart 3 is part of the "Systematic Chart to understand facts about attractive functions".

This task responds to the attractive function version of sorting out items required at planning. By utilizing this technique, all the members became aware that attractive functions that had been confined in the world of image and left to designers were related to useful functions. This can be said to have contributed to quality guarantee activities of the product.

4.3 Establishment of developmental design target cost by utilizing cost analysis by function

Now, the author introduces a method to allocate permissible cost price of the products set to each functional sector in the systematic chart of functions required at planning. It was intended to strengthen the guarantee activity of the product cost by the task. In terms of VE, it is an implementation of the "design-to-cost" practice. In other words, the cost guarantee activity of concurrent engineering can be termed as the cost price planning activity.

The functional analysis stage of the Development VE includes up to the establishment of development design target cost. After this, development VE will be sophisticated to the basic design chart via the Creation Stage.



Each function is defined from either of customer satisfaction factors

Chart 4: Systematic Chart of (Useful) Functions Required at Planning

Customer satisfaction factor	Degree of influence (in %)	Permissible cost price by factor (all permissible cost prices 100)	To store unhulled rice	To generate heat	To circulate unhulled rice	To control drying operation
Basic function	14	100 × 0.14 = 14		7.0	7.0	
Operability	10	100 × 0.10 = 10				10.0

Tentative evaluation value		100	12	40.0	30.0	5.0
Cost adjustment		±0	+1	-1	-0.4	-0.6
Decided value of development design target cost by function (functional evaluation value)			13	39	29.6	

Chart 5: Example of Establishing Development Design Target Cost

(Function Evaluation Value)

5. TOWARD CONSTRUCTION OF LEAN ENGINEERING SYSTEM

If only one case of new product development activities (this case) could demonstrate effects of concurrent engineering, it means nothing if it fails the second time and after. It is usual for new products developed by a company to be frequently serialized. A development system that can take out effects of concurrent engineering continuously and with an extremely high probability is sought.

First of all, therefore, a standard development process of new product by product group unique to a company must be designed, and a system that allows constant product development according to the process must be formed. In this case, it is nothing but organizing a system where product development is conducted under the TFP method, DR is effectively implemented on the way and information tool is positively utilized (mainly

focused on in-house e-mail).

Moreover, the author would like to propose utilization of the VE techniques as a standard technique to develop new products. For a different product in the same product group, utilization of the VE techniques will reduce overburden (muri), waste (mura) and unevenness (muda) of development activities and effects of concurrent engineering can be further secured.

In the future, effects of concurrent engineering must be expanded from line (a single new product development) to plane (new product development of a series of product group). From now on, the author would like to name this new product development system: the Lean Engineering System.

6. EVALUATION METHOD AFTER NEW PRODUCT DEVELOPMENT THROUGH PRACTICE OF LEAN ENGINEERING

It is difficult to objectively evaluate new product development activities. The author examined a method to estimate enhanced value of new products based on the VE conceptual formula V=3DF/C and with lead-time variables newly added. The author would like finally to propose this calculation formula.

V=Qn x C-n x D-n=Qn/Cn x Dn - (1)

V: Value improvement ratio of developed new products

Qn: Quality improvement ratio, Cn: Cost reduction rate

Cn=Ca/Cb - (2)

Cb: Pre-development cost (manufacturing cost of obsolete machine)

Ca: Actual cost price of developed machine (manufacturing cost)

Dn: Lead-time reduction rate

Dn=Da/Db - (3)

Db: Real development period of obsolete machine

Da: Actual development period of machine

Qn=(Qa1/Qb1) x W1 + - - + (Qan/Qbn) x Wn= Σ (Qai/Qbi) x W1 - (4)

Qbi: Standard value of quality item i in obsolete machine

Qai: New standard value of quality item i achieved in developed machine

Wi: Degree of influence (%) of customer satisfaction factor related to Qbi and Qai

The following is actual examples in A1.

As for Qn, it naturally equals 1 when quality items are not different from obsolete machine. Please note that if lower values indicate improvement, a denominator and numerator of Qn will be reversed (Qbi/Qai).

Qb1: Burner sound of obsolete machine=10(index)

Qa1: Burner sound of new machine = 8(index)

W1: Degree of influence of amenity =0.10

Qb2: Obsolete design=10(index)

Qa1: A1 design=13(index)

W2: Degree of influence of taste=0.05

Cn=Ca/Cb=89/100=0.89

Dn=Da/Db=15/27=0.55

Qn=10/8*0.1+13/10*0.05+0.14+0.10+0.04+0.1+0.13+ 0.11+0.16+0.06=1.025

Therefore, V=1.025 divided by (0.89 × 0.55)=2.13

PS Design indexes are taken out from interview conducted for customers when the number of customers satisfied with the design of obsolete machine is designated as 10. For other design quality items, the number is similar and the quality ratio becomes 1.

Thus, the value of V of new product A1 (value enhancement ratio) is found as 2.13 and the degree of effect can be obtained quantitatively. In the future, it seems that degrees of effects are required to be made more objectives by applying the formula to other products.

7. CONCLUSION

As has been stated in this paper that Lean Engineering is a system that promotes new product development by the TFP method in accordance with the process based on VE as well as implementation of DR. The author would urge medium-sized enterprises with higher flexibility to aggressively adopt the system. In the future, therefore, the author would like to investigate into a method that can systematize in particular the relationship between attractive and useful functions more logically. The author would finally like to consider a more effective product evaluation method in which systematized functions are added to evaluation elements.

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