DESIGN FOR MANUFACTURABILITY AND ASSEMBLY (DFMA) PRODUCTIVITY EVALUATION USEFUL TO VE ACTIVITIES

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ABSTRACT

The VE method with enhanced productivity evaluation function is effective for the Q.C.D. improvement activities at early stages of development. This paper describes some weakpoints of VE activities as seen from productivity evaluation, as well as what causes, and how to overcome, such weakpoints. Thus we can effectively build DFMA procedures into VE job steps.

INTRODUCTION

More than 80% of a product cost is generally s aid to depend on the results of engineering activities in the early development stages (Product Planning and Designing). For this reason, application of VE methods in such early stages has been considered more effective than in the other stages, and VE activities have been aggressively carried out in these stages. Recently, more attention has been focused on the simultaneous engineering activities of development and manufacturing departments to further improve Q.C.D. by addressing manufacturing in the early stages.

In view of manufacturing costs, VE methods have been often applied to saving material and machining costs which account for 80 to 90% of the manufacturing costs. The other 10 to 20% of the manufacturing costs, for which VE methods and standards are not yet established.

In a strict sense, VE methods and standards for evaluating productivity are not fully provided for the machining costs. This is because most of workers' efforts are focused on operating actual machines and dealing with given works, and thus necessity for changing design and modifying parts sometimes arises in manufacturing stages.

Therefore, simultaneous, joint VE activities of development and manufacturing departments in the early development stages will evidently turn out to be essential and efficient in building up Q.C.D.

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

This paper proposes a new VE method as astandard technique which can not only be shared by both development and manufacturing departments, but also compensate for the weakness for productivity evaluation.

Productivity is generally expresses as follows:
Productivity can be placed in two categories, labor and facility productivities, according to the resources employed, and can be expressed in terms of cost, time and volume:

(1) Labor Productivity

$$\text{Labaor Productivity} = \frac{\text{Output: Price, Operation Time Production Volume, etc.}}{\text{Input: Number of Opereators, Labor Costs, etc.}}$$

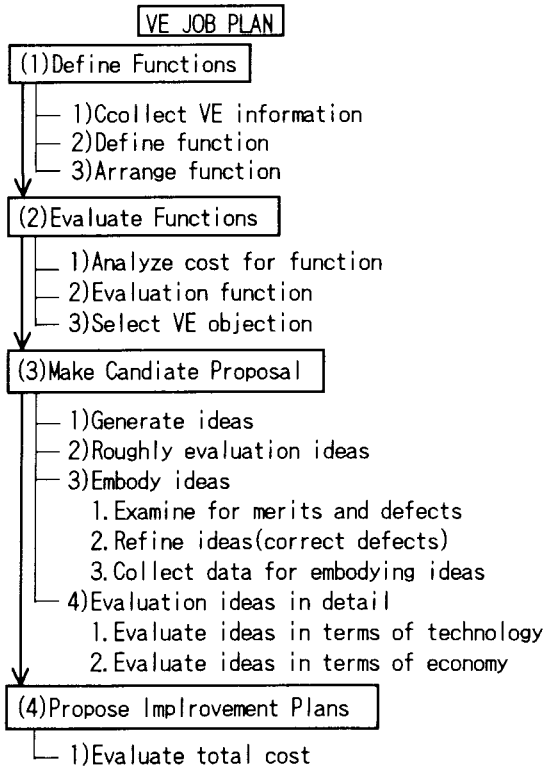
(2) Facility Productivity

$$\text{Facility Productivity} = \frac{\text{Output: Price, Opereation Time Facility Costs, etc.}}{\text{Input: Number of Facilities, Production Volume, etc.}}$$

In this paper efforts are focused mainly on the evaluation of time and cost required in machining and assembling parts in terms of labor productivity.

CURRENT VE ACTIVITIES AND PRODUCTIVITY EVALUATION

VE activities are conducted according to the following VE job plan :



Figl. VE Job PLan

As seen in the diagram, efforts in VE activities are focused on creativity by pursuing functions, generating and embodying ideas. Therefore, VE methods can be considered as techmiques for optimizing design with functions. As a result, functions demanded by users are closely pursued in VE activities with manufacturability and easiness in assembling operations neglected.

For this reason, problems in VE methods have been in terms of productivity. Assumed causes and possible solutions of the problems are listed as follows :

(1) Traps VE Engineers Are Likely To Fall Into

1) In the VE job step of generating ideas, manufacturability is likely to be neglected because high priority is given to the achievement of functions.

2) In combining ideas in the VE job step of embodying ideas, manufacturability is little considered.

3) In the VE job step of examining for merits and defects, and correcting defects, manufacturability is scarcely studied before the VE job step of refining ideas.

Because of these traps, our efforts sometimes result in poor manufacturability when the ideas about functions are embodied. In some cases, parts and equipment made according to the best VE proposal reveal poor manufacturability when they are fitted together with related parts and equipment in assemblies.

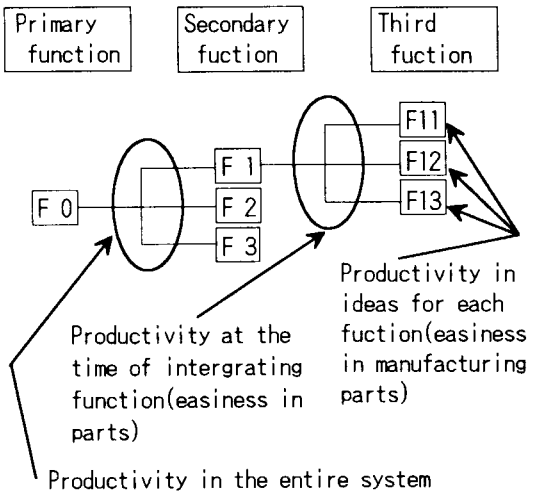


Fig2. Productivity in Function Intergrating Diagram

(2) Assumed Causes and Possible Solution

< Causes >

1) A job step of studying productivity is not shown in the VE job plan.

2) A method for objectively evaluating productivity in the VE activities is not stated.

3) As a result, a system for improving productivity is not yet established.

< Possible Solution >

Considering the above assumed causes, the problems will be solved by integrating the method for

objectively evaluating productivity and the technique for improving productivity into the VE job steps.

PRODUCTIVITY EVALUATION IN VE ACTIVITIES

The following three points are necessary coditions for productivity evaluation :

(1) Time and cost required in machinin and assembling parts can be quantitatively understood.

(2) Points in productivity improvement can be clarified.

(3) Effects of improvement plans can be evaluated in a short time.

Methods and techniques that can be introduced into the VE steps have been studied with these points kept in mind. One of the potential means of evaluating productivity is DFMA, Design for Manufacturability and Assembly, to be used at the early development stages to improve efficiency in the simultaneous engineering activities of development and manufacturing departments. Proposed here is integration of the DFMA method into the VE job steps.

DFMA is a technique for improving productivity, developed in the early 1980s by Professor Geoffry Boothroyd, Professor Peter Dewhurst and Professor Winston Knight at Rhode Island U niversity. This method has been deployed and used, not only in the major manufacturing companies but also in many other companies as a means of rejuvenating the manufacturing industry in the United States, producing considerable effects. Also in Japan, electrical and automobile companies as well as many others started introducing this method.

The DFMA method is used in two ways for analyzing manufacturability, DFM, and easiness in assembly, DFA.

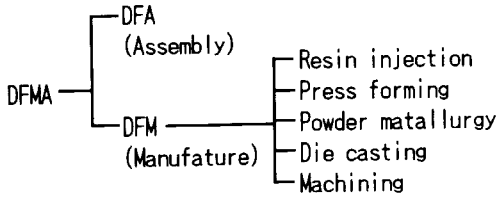


Fig3. DFMA

The results of analyzing manufacturability, or machining techniques, are usually incorporated in the engineering stage into products as suppliers' know-how. Therefore, manufacturability varies from supplier to supplier. DFM is a technique for quantitatively evaluating and pursuing optimum manufacturability.

DFA is a means of checking easiness in assembling parts in engineering stages, and is very useful in simultaneous engineering.

Objection of DFMA(DFA)

1) Reducing manufacturing cost by improving productivity.

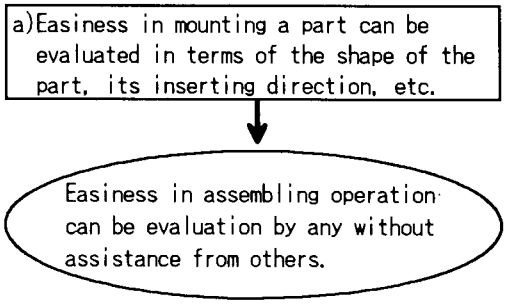
2) Dealing with manufacturing problems in advance by applying the method in the early development stages.

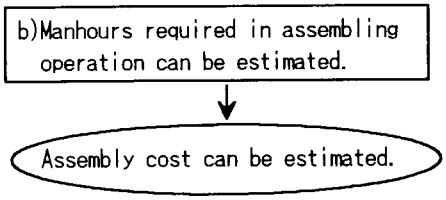
3) Simultaneous engineering by team design activities.

Features of DFA

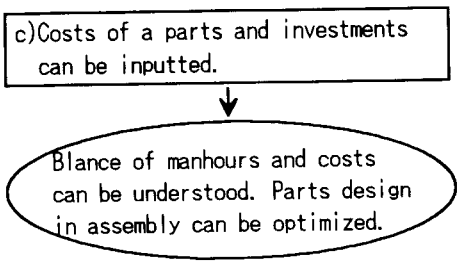
The following are the major features of DFA:

1) Productivity can be evaluated for each part:





2) Easiness in assembling operation can be quantified.



3) Points in improving productivity can be identified.

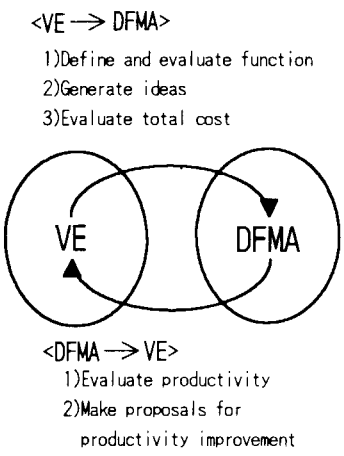


Fig. 4Compensatory Relation Between VE and DFMA

4) DFA program can be run on a general personal computer.

Operation is easy because of the interactive mode. Data is easy to correct, and a variety of simulation program can be run at the same time.

Features of DFM

The following are the major features of DFM:

1) Costs can be evaluated for parts with different materials and dimensions.
2) Manufacturability can be quantified. (Manhours can be evaluated for each manufacturing method, process and machine.)
3) Costs of parts can be evaluated and compared with those of parts manufactured by a different process.
4) Evaluation results can be readily obtained by using a personal computer.
5) Design can be optimized in terms of manufacturability.

In summary, the most prominent feature of the DFMA method is that all the evaluation results are automatically obtained by the interactive program. Productivity can be evaluated from both assembling and machining points of view by using DFA together with DFM, and thus product design with a high productivity can be achieved.

Disadvantages of DFMA

The following are the disadavntages of DFMA:

1) Approaches to function evaluation are not fully provided. Since the productivity evaluation process is not provided with the step of studying functions, such improvement proposals are sometimes made that parts with functions, mostly secondary and auxiliary ones, are integrated or cease to be used, or in some case parts fail to meet function requirements due to change in manufacturing method.
2) Ideas are not sufficiently generated. The conventional DFMA method is not provided with the step of generating ideas systematically, and thus ideas about improvement are not always sufficiently generated and embodied.

Relation Between VE and DFMA

Necessity for compensating for each other's disadvantages, as shown below, arises in devising a VE method, with which productivity can be evaluated, based on the aforementioned advantages and disadvantages of the DFMA method.

Points of view on evaluating and improving productivity, which the conventional VE mettod lacks, can be grasped by means of DFMA. In addition, the DFMA method can be integrated into the VE job steps by applying the VE method for generating ideas.

Because of such compensatory relationship, the following effects can be produced :

1) In the VE method, productivity improvement can be quantitatively understood and evaluated.
2) In the DFMA method, productivity improvement proposals can be made without losing functions.

This means that a new process of evaluating productivity is integrated into the VE method. As a result, productivity is improved by the VE method, and our chief objective of value improvement will be achieved.

$$VE = \frac{F}{C}$$

*By introducing DFMA, design with optimum productivity can be obtained, and manufacturing cost can be minimized.

INTRODUCTION OF DFMA IN VE

In introducing DFMA in VE, the following two points should be dealt with :

(1) By providing the VE technique with the capability of evaluating productivity, the technique can be used in the simultaneous engineering by development and manufacturing departments.

(2) The VE activities can be made more valuable by studying productivity in the initial development stages, that are conventionally studied in the final manufacturing stage.

Points in introducing DFMA in the VE job steps are summarized in Fig. 5.

The following results are expected to be made by introducing DFMA in VE :

(1) Efficiency in development can be improved by dealing with productivity, which in the VE activities, is conventonally studied in a late stage, in the early development stages.

(2) VE activities can be development by using the standard technique as acommon tool in the simultaneous engineering activities of development and manufacturing departments.

CONCLUSION

The method of introducing DFMA in the VE job steps has been discussed in this paper as a supplementary means of evaluating productivity in the VE activities.

Advanced corporations have already introduced DFMA methods, and have confirmed significant results from its application. Significant results can be expected from application of the new method discussed in this paper as well.

The new job plan, in which DFMA is integrated into VE, is cosidered effective from the results of applying the method in to few actual cases by us. This VE job plan, however, is not yet in its established complete from capable of meeting various project requirements or VE conditions.

In the future the new VE job plan will be carried out in an actual activities to verify its effects, to establish it in its higher stage of completion.

Joint simultaneous engineering of development and manufacturing departments at the early development stages to build-up Q.C.D. is not only essential, but very efficient in conducting development activities. And in actual execution, both VE and DFMA are cosidered as effective management techniques.

REFERENCE

(1) VM Center of Reseach Institute, Sanno College, " Basics of VE ", 1986

(2) BDI. " DFA/DFM Text ", 1982

VE Job Steps	Points in Introducing DFMA
(1) Collect VE information (2) Define functions (3) Arrange functions (4) Analyze cost for each function	← Understand the current productivity quantitatively by means of DFMA. <Objective> Clarify productivity improvement targets.
(5) Evaluate functions (6) Select function groups to improve	
(7) Generate ideas	← Propose ideas in view of productivity improvement.
(8) Evaluation ideas roughly	← Add productivity level to evaluation items. Overcome disadvantages by checking productivity in evaluating advantages and disadvantages. <Objective> Clarify points of improvement in producivity by means of DFMA, and make productivity improvement proposals which solidly meet function requirements.
(9) Embody ideas (10)Evaluate ideas in detail *Make improvement proposals*	← Evaluate productivity <Objective> By comparing them with those of the current methods. Understand productivities of the improvement proposals.

Fig. 5Introduction of DFMA in VE Job Steps