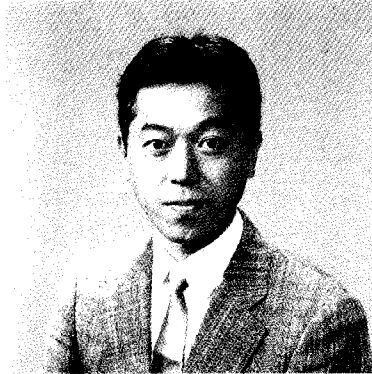


## VALUE ENGINEERING FOR PRODUCTION FACILITIES

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### ABSTRACT

In the current Value Engineering (VE) activities, complete productivity evaluation and improvement technique has not yet been established to be used in the initial stage of product development. This paper deals with a method for improving productivity of a product by conducting the VE activities on production facilities in the initial stage of development.

departments participate in the activities from the beginning in order to improve performance, quality and cost of a product in the early stage of development, and also to greatly reduce development lead time.

By conducting the CE activities, problems are identified at an early stage, and policies for corrective action are made. As a result, design changes and manning plans are made in advance, and the overall manufacturing lead time is cut down, though planning and concept development require a longer lead time.

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### CONCURRENT ENGINEERING (CE) AND VE

Keen attention has been focused on concurrent engineering (CE), in which planning, engineering, tryout and production preparation activities are simultaneously conducted. According to the report made by the Institute for Defense Analysis (IDA) in the United States, concurrent engineering is a systematic approach with which engineering activities are integrated and concurrently conducted on products and their manufacturing processes as well as supporting systems. Such engineering approach is designed to have engineers consider every element of a product in life cycle from product planning to disposal, such as quality, cost, schedule and demands from users, in the initial stage of development.

Information processing/retrieving techniques are indispensable for CE. In order to conduct the engineering activities concurrently, information about results of the activities of other groups should be obtained at any time. Real time information about results of the other group's activities is necessary and should be shared in the CE activities. In this sense, a computer network system is essential for achieving a goal in the activity. In the case of different departments using different systems, interface is required. Sharing real time information is impossible if, for example, an engineer with a production department who wants data obtained and stored by a development department is required to input data in the computer system of the production department.

In the CE activities, engineers with different

In addition to the preparation of hardware of computer system, a control method common to

planning, development and production stages is necessary for CE. As seen from the afore-mentioned definition of CE, CE shares part of its concept with VE. Therefore, VE is considered as a very useful technique for achieving the goals of CE.

#### PRODUCTIVITY EVALUATION BY USING DFMA

Most of new products in the mature stage are not totally new, but more often modified ones to compete with other maker's models by adding models or having a low price setting. In most cases, manufacturing methods have been reviewed in order to achieve better quality at a low cost. Therefore, evaluation and improvement of productivity in the initial stage of development is critical.

In the conventional VE activities, efforts have been focused on cost saving in the early stage of development, and many good results have been achieved. Recently, Design for Manufacture and Assembly (DFMA) has been introduced in VE activities as a supplementary means to evaluate productivity.

DFMA is an engineering support software for improving productivity, developed by Boothroyd Dewhurst. With this software, productivity of a part is analyzed and evaluated before drawing release by inputting the order of assembling parts, and also the shapes and characteristics of parts. As a result, designing a product easy to assemble and process has become possible, and thus manufacturing costs, such as die/jig costs and parts control costs, have been reduced. In addition, this software is widely applicable to other purposes, such as manhour control and process designing. A number of improvements have been reported, especially in the United States.

Standards for quantitatively evaluating productivity with DFMA are set in the database of the software. For example, the following assumptions are granted for evaluating assemblability:

- ① Operators handle works on tables; Operator's working positions are not considered.
- ② Parts and tools are placed within reach of operators; Transferring works is not considered.
- ③ Parts are randomly placed in a box; Conditions of delivered parts are not considered.

- ④ Operation of picking parts by checking specifications is not considered.
- ⑤ Fasteners are tightened by such means as power drills.
- ⑥ Operator's skill levels are not considered; All assumed to be standard.

Results obtained by calculation with DFMA are standard manhours required for dealing with part shapes and the number of parts. Therefore, such results are different from the manhours actually spent in a plant assembly line as DFMA is basically designed for evaluating the level of completion in design.

DFMA is designed to run on a personal computer, and data is input in an interactive manner so that every engineer can use the software easily. As the productivity evaluation standards of DFMA are invariable, the software can be shared by development and production departments as a common tool for studying and comparing productivity of a product.

In comparison with VE, which does not deal with productivity evaluation and improvement, DFMA is not provided with function analysis and idea generation methods. Each other's shortcomings are compensated for by introducing DFMA into VE job steps to have more useful VE method. As a result, we can design a new product with a high productivity by carrying out VE activities considering the productivity of a product in the initial stage of development.

However, in reality, production preparation has been started in a passive manner after all the details of product design are determined, though a new product design with high productivity is achieved by the introduction of DFMA.

In a conventional way of developing a new product, production engineers evaluate productivity after all the detailed design has been completed. In reality, improvement proposals are made by production engineers, but most of them are not carried out because design changes after drawing release is restricted to those for trouble shooting. Otherwise, development of a new product will largely fall behind schedule. Production engineers are not given sufficient time to improve productivity and production quality. Therefore, no matter how effective proposals for productivity improvement

are made, they are saved for the next product planning, and thus not reflected on a product soon, which as a result discourages production engineers from making proposals.

In many cases, production engineers focus their efforts on achieving accuracies and quality levels specified in a product drawing, and seldom try to find out why they need the accuracies and quality levels. As a matter of fact, in some cases, such high accuracies are not necessary for a product to meet functional requirements.

VE activities are not provided with an aspect of productivity evaluation and improvement. This is only because the activities have been carried out mainly by product designing engineers in the initial stage of a product development. This means that product designing engineers, not VE, are poor at dealing with productivity. Therefore, DFMA is considered as an effective support means for conducting VE activities under the leadership of development engineers.

Also, in some cases, production engineers participate in VE activities in the early stage of development in order to save manufacturing cost. In the development stage, however, production preparation is not yet begun, and thus possibilities of improving productivity is roughly studied, and not intensively. Production preparation should be started concurrently with product designing in order to study productivity, which is characteristic of a product, more elaborately and concretely.

#### PROBLEMS AND SOLUTIONS ON VE FOR PRODUCTION FACILITIES

Conventionally, our VE activities are mainly carried out in the early stages of development, and DFMA has been used for studying productivity. However, little VE activity has been developed in the stage of production preparation, especially for production facilities. This is because of the sequential flow of the development processes, in which production preparation starts only after product design has been completed. Such a manner of development has the following problems:

- ① Product shape is difficult to change.
- ② Remarkable effect is not expected only by reducing the costs of production facilities
- ③ Production engineers have little experience of VE.

The above problem ① is such a case where investment in production facilities can be saved, but a design change of a product should be avoided because of little time left for design change in the development schedule. As a result, facility costs are prevented from being saved.

The above problem ② is that facility cost-saving activities without allowing any changes in a product shape is little effective, considering long manhours spent. In the case of volume production of a product, cost saving effect becomes more striking as production volume increases, even if a cost saving in a single product is very small. Facilities specifically designed for a product, however, have little versatility, and are difficult to use in the other lines. The objective of VE for production facilities is not saving cost, but improving productivity.

The above problem ③ is that there are very few value engineers in our production departments as VE activities have been mainly conducted by development engineers. Even production engineers with an experience of participating in development engineers' VE activities have little chance of using VE techniques, and thus cannot improve proficiency in VE.

The most critical point in introducing VE in the stage of production preparation is timing for starting production preparation because little VE activity is conducted. in the stage.

With the concurrent engineering introduced, product drawings are no more restraining conditions of VE activities for production facilities. Therefore, changing product shape has become possible in the VE activities for production facilities within the framework of development schedule. As a result, a great effect is expected even by VE for production facilities.

Indispensable to the achievement of this goal is computer network system. Sharing real time information between development and production departments is necessary in order to conduct VE activities for production facilities concurrently with development activities. Especially, information about product shape should be given in a form of CAD data so that the information can be mutually retrieved at any time.

Production engineers, of course, need to take part in the VE activities, but most of them are not value engineers, and thus lack in the experience of value engineering. Without knowledge and techniques about VE, conducting VE activities is impossible. In order to solve this problem, the VE activities should be conducted in such a manner as work shop seminars (WSS), and the seminars should be held until the system is established.

In the VE activities for production facilities in the seminars, our efforts should be focused on the following points :

① VE team members should be in charge of, or involved in the project.

Unless the members' objectives are related to the goals of VE activities, concrete improvement proposals are not made, or the activities will end up in only education. In this respect, only those involved in the project can conduct the activities by sharing real time information with other department engineers. Without information about the product to be developed, proposals made by production engineers would serve no purpose, or desired products cannot be produced with the facilities.

A VE team should be made up of experts in product engineering, facility engineering, production process planning, maintenance and manufacturing. The best way to conduct the activities is to have engineers in charge of project from each department/section participate in VE activities, and carry out VE activities concurrently with the other everyday activities. Essential to success in the VE activities is to compensate for each other's shortcomings in VE skill, and add/change team members if a VE team lacks any VE skill.

② A leader should be assigned to each VE team.

As there are few value engineers in production department, an engineer abundant in experience and knowledge about VE, as well as leadership, should be assigned to a VE team leader instead of assembling a team and selecting a team leader from the members. VE activities should be conducted so that a team member poor in experience and knowledge of VE will win success.

③ All the basic VE procedures should be followed.

As one of the objectives of conducting VE seminar activities is to develop a VE engineer, all the basic VE procedures should be followed. All the

VE concepts and points should be learned for the next activities, though, in actual VE activities, some VE steps are saved if not applicable.

### VE JOB STEPS AND APPLICATION TO PRODUCTION FACILITIES

Conventionally, old facilities are scrapped, and then new facilities are in-stalled to have a new production line. All the facilities in a new production line are either purchased or newly designed and manufactured. The following shows a case of modifying facilities which are expected to be scrapped, and introducing them into a new production line:

Facilities for machining an automotive axle part were dealt with in our VE activities. This machining line was planned to be a new line due to model change.

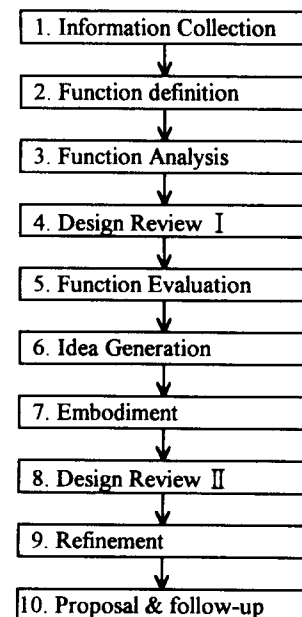


Figure 1. VE Job Steps for Production Facilities

#### Information Collection

Accurate information about overall project schedule, facility schedule, production process plans, and especially maximum investment in facilities is necessary. Also, collection of information about the axle part is indispensable. In the case of conducting

product engineering concurrently with VE for production facilities, real time information/data should be checked for any design change in any job step shown in Figure 1.

Function Definition

The purposes of using the facilities, functional requirements for the facilities, as well as means of achieving functions, should be determined

Table 1. Functional Requirements

Requirement	Means	Machining Order
Make Inner Circumferential Surface	Milling	1 <sup>st</sup> Process
Make Outer Circumferential Surface	Lathing	2 <sup>nd</sup> , 3 <sup>rd</sup> Processes
Smooth Surface	Grinding	6 <sup>th</sup> Process
Drill Holes	Grooving	4 <sup>th</sup> Process
Cut Grooves	Grinding	5 <sup>th</sup> Process

Function Analysis

Functional requirements for facilities are analyzed with a function diagram (See Figure 2). Then the functions of the used facilities are analyzed for comparison with the functional requirements. Such used facilities with more functions than required

should be selected. Redundant functions are neglected. Unnecessary facilities are regarded as scrap unless they are employed, but value improves by using them.

Functional requirements are compared with the functions of the used facilities to determine what functions are necessary (See Table 2).

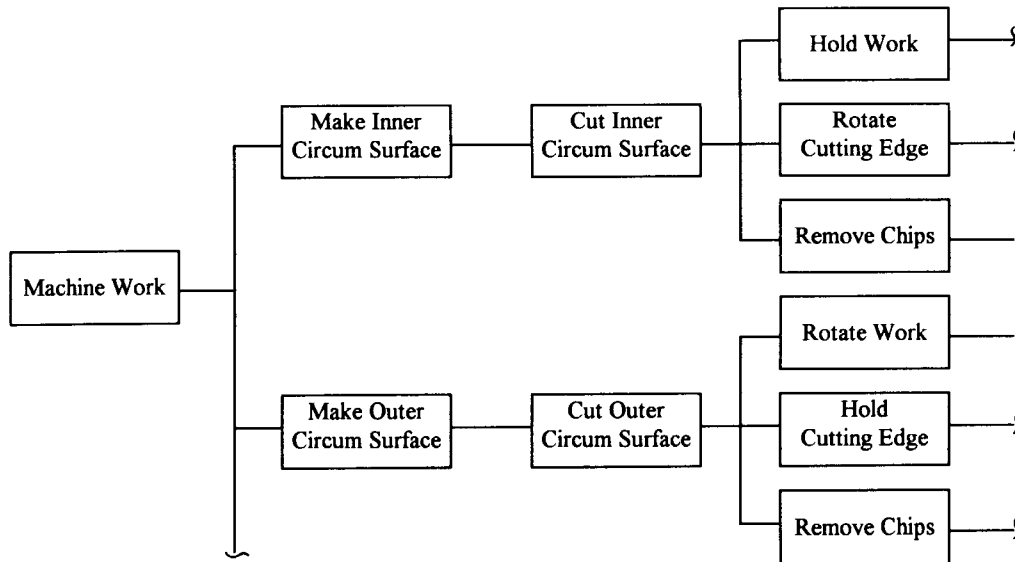


Figure 2. Function Diagram

Table 2. Insufficient Functions in Used Facilities

Process	Facility Name	Insufficient Functions
Milling	Milling Machine	Work transfer and setting, cutting edge shape
Lathing	Lathe	Work transfer and setting
Lathing	Lathe	Work transfer and setting, cutting edge shape
Drilling	Drilling Machine	Work transfer and setting, cutting edge shape, insufficient number of spindles (can not be drilled within cycle time)
Grooving	Machining Center	Work transfer and setting, cutting edge shape
Grinding	No Facility	

Design Review I (DR- I )

Some proposals are not accepted because of lack of restraining conditions and inappropriate definition of functions, even if considerable manhours are spent. Design is reviewed twice before proposals are put forward in order to check that correct direction is kept followed, and to correct it, if not. DR- I is conducted as follows:

① VE theme selected by managers are studied by VE team in terms of the functions of a product, applicable range, deadline, investment in facilities, and the study results are reported to the managers. Targets for cost saving in investment by VE activities are set considering the amount of investment and the term for amortization. Also, the results of studying the profitability of VE activities are presented in terms of target effect versus cost of VE activity.

② VE team members' understanding of functions is presented using function diagrams, as well as the possibilities of a product meeting the restraining conditions and the goals being achieved.

③ VE team members seek advice from the managers, those with experience, and those who use the conventional facilities. With all the confirmations made, VE activities are again conducted under the leadership of VE team.

Function Evaluation

Costs for achieving insufficient necessary functions are determined to know the amount of investment required for each function.

Cost of machining a product is calculated by means of DFMA. In many cases, calculation results are different from actual costs, but DFMA helps us readily understand the points in improvement and the effect of proposals on cost saving by using a computer.

Idea Generation

Ideas are generated for using the current facilities instead of manufacturing new ones, and compensating for insufficient functions. Also, ideas are gained for improving productivity in the machining line of a product.

Embodiment

Proposals for improving value are made by combining ideas. Decisions are made on the use of unnecessary facilities for each machining process. The purpose of VE for production facilities is not only saving costs of facilities, but also improving the productivity of a product. Therefore, proposals should be made not only for improving production facilities themselves, but also for improving the productivity of a product, though, in the case shown in this paper, proposals for improving productivity are not made.