



THE APPLICATION OF PROCESS MANAGEMENT FOR RELIABILITY ENHANCEMENT OF THE TAGUCHI METHOD

Marcelo Henrique Sestren

Aluno de mestrado do Programa de Pós-Graduação em Engenharia de Produção
Universidade Federal de Santa Catarina – Florianópolis (SC)

Miguel Fiod Neto

Departamento de Engenharia de Produção e Sistemas
Centro Tecnológico - Universidade Federal de Santa Catarina
(88040-900) Florianópolis (SC)
E-mail: fiodneto@eps.ufsc.br

Abstract. *The concept of Process Management has been used by managers and consultants that search for the improvement of both operational or managerial industrial processes. Its strength is in focusing on the external client and on the optimization of the internal process in order to fulfill their needs. By the time the needs of internal clients are being sought, a set of improvements takes place. The Taguchi method, because of its claim for knowledge share between design engineers and people engaged in the process, is a candidate for process management implementation. The objective of this paper is to propose that kind of application aiming for improvements related with reliability of results revealed by the robust design of Taguchi method.*

Key words: process management, quality management, Taguchi method.

1. INTRODUCTION

The Design of Experiments (DOE) plays an important and strategic role in companies that wish to attain leadership in the marketplace. Its goal is to identify factors, technical or otherwise, that impact significantly the performance of products or services. Thus, targets can be set taking into account the strengths and weaknesses within the process. Undoubtedly this is a crucial part of an off-line quality control (Hendrix, 1990).

The Taguchi method brings a new approach to the purely statistical one which has been used for decades by experimental engineering. Genichi Taguchi proposed the use of knowledge accumulated by companies' engineers and technicians, as a starting point for experimental studies. By doing this, Taguchi was able to reduce significantly the number of experiments by applying *orthogonal matrixes and triangular tables*, also developed by him. The method is complemented by the concept of *function-loss, design by parameters, design by tolerances* and *signal-noise ratio* (Phadke, 1989).

However, the Taguchi method is strongly opposed by traditional statisticians who argue that it lacks scientific consistency and show cases in which its application clearly led to wrong results (Ryan, 1988). There is a divergence concerning the validity of using knowledge about the process that has been accumulated by the people involved, and about the way this information is obtained and utilized in the method (Fiod, 1997).

Controversies apart, the fact is that many companies, particularly the Japanese, have gained a great competitive edge by improving their products/processes/services based on the Taguchi method. Perhaps the origin of many failures faced by Westerners when applying methodologies that are commonly used in Japan is due to the fact that Asians have a deeper philosophical awareness of what they are applying, whereas in the West, a more methodic and rational execution is sought when the same concept is applied. Numerous examples illustrate this case and are related to Total Quality Control and methodologies such as the 5S and Quality Control Circles in which the application typically takes place within the company and is established through the simple filling out of tables and boards, without the actual attitudinal change expected from individuals. An example of the consequence of this type of failure are the statistical data recorded in several Brazilian states, that indicate a high rate of failure in the introduction of such programs in companies.

A concept that has been used by companies to ensure the meeting of its clients' needs is that of Process Management. In this concept, the company is viewed as a macroprocess, the inputs of which come from some suppliers and its output are goods and/or services that are made available to the client. The macroprocess is broken down into subprocesses and these, in turn, into activities. A chain (value chain) of clients and internal and external suppliers is then set up. Its goal is to achieve the efficient fulfillment of all clients and suppliers, which leads to excellent quality and productivity results. Many unnecessary activities and subprocesses are eliminated, in addition to the *noise* that distorts the goal of the macroprocess.

This article is about the utilization of Process Management as a means of establishing the activity sequence that is required to put the Taguchi method into practice. Its purpose is to highlight the activities that are potentially important for the experiment being studied and to establish a well-defined procedure to be followed by the design team in order to eliminate distortions leading to wrong conclusions, or at least to reduce the likelihood of such things ever occurring.

Probably, the application of Process Management to reduce *noise* when applying the Taguchi method will not quiet down its opponents, but will certainly make it more reliable for those who use it and will encourage people from different areas in the company to team up with the design staff.

Process Management will follow some procedure sequences cited by the researchers of the Taguchi method. It must be pointed out, however, that there is no rigid rule regarding its application.

2. THE PRINCIPLE OF PROCESS MANAGEMENT

Researchers of fields related to quality and productivity improvement, strategic cost management, reengineering, etc. have reported the use of methodologies to achieve improvements in companies. What many of these methodologies have in common is the use of the client-supplier concept to identify actual needs within the company and to determine if such needs are coherent with the goals of the business plan. Juran (1992) describes the input-output diagram based on the triple-role concept: "each unit of the organization – the company as a whole, each division, department and person – performs a process and produces a product". Juran calls any of these units *processing team*. "Each processing team plays three quality-related roles which are described by the TRIPROL[®] diagram" shown on Fig. 1.

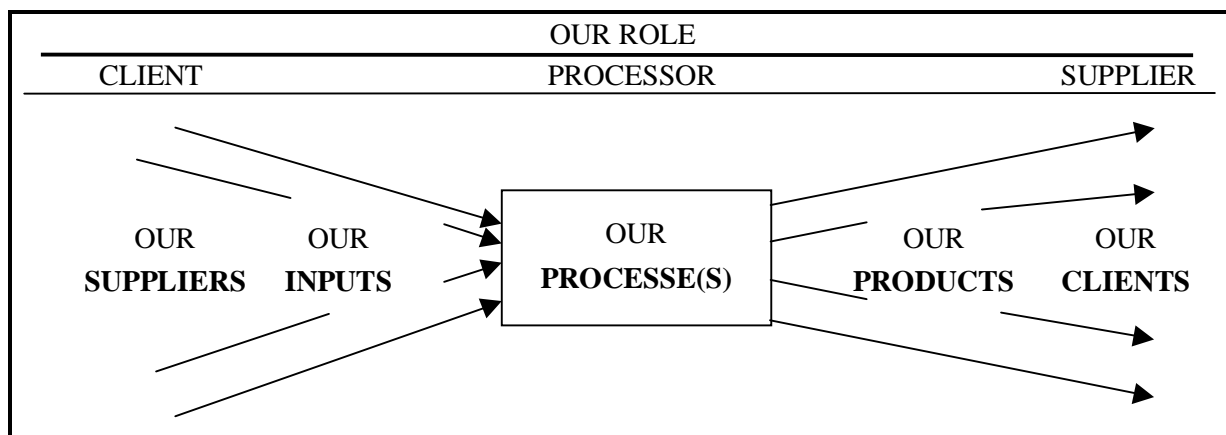


Figure 1 - The Tripol® Diagram. Source: Juran (1992).

The diagram on Fig. 1 illustrates the interrelationship of these three roles, namely:

- *Client*: the processing team needs several types of inputs in order to carry out its process. The team is the client of suppliers who provide the inputs it needs;
- *Processor*: whatever the nature of the processing team (managerial or technological), it must perform several activities to finish its products;
- *Supplier*: the processing team supplies its products to its clients who in turn are the subsequent processing teams in the value chain.

On the other hand, Ostrenga (1993) proposes in his methodology for the analysis of the business process, the drawing of a relationship diagram for the case of a “process of ordering materials”, as shown on Fig. 2.

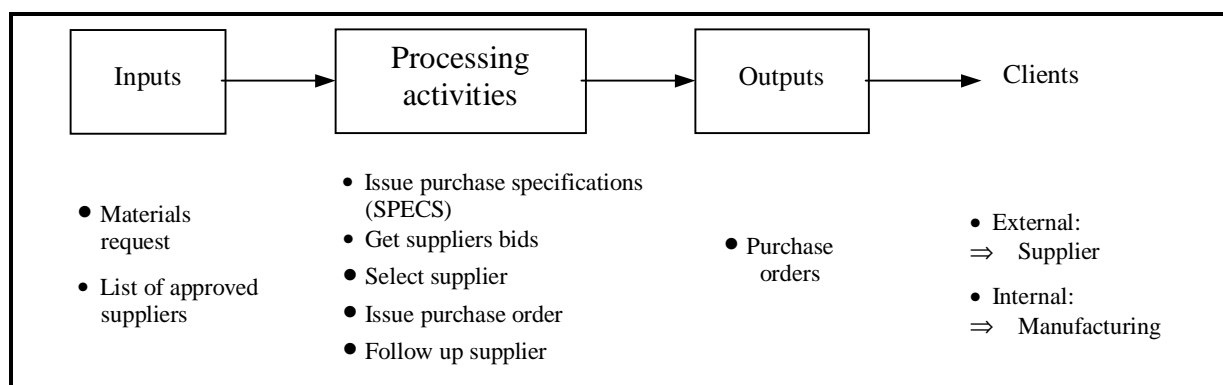


Figure 2 - Process model: ordering materials (example). Source: Ostrenga (1993).

When a client-supplier diagram is obtained for all the processing teams that are interconnected in the company, we are automatically obtaining the chain value map. This provides an understanding of the organization as a whole, which consists of a fundamental phase of the Perfecting of Corporate/Business Processes described by Harrington (1993) and shown on Fig. 3.

It should be noted that these three authors utilize similar methodologies, although they assign different objectives as far as usage is concerned. Juran stresses the quality of products and services as final goals, and seeks a way of enhancing the efficiency of subprocesses in the performance of the quality plan set up by the top management. Ostrenga, on the other hand, uses his methodology as a starting point for the efficient structuring of the corporate/business

process, in order to set up an Activity-Based Costing system (ABC) and an organization for on-going improvement. Harrington is more geared towards process improvement. Actually, all of them deal with the same issue, but from different perspectives.

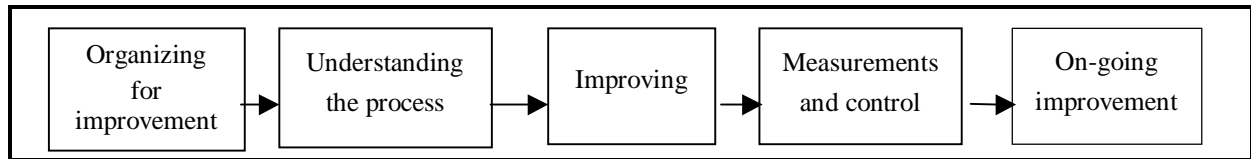


Figure 3 - The five fases in the improvement of corporate/business process.
Source: Harrington (1993).

Several other authors, managers and consultants argue in favor of and adopt similar methodologies, both in theory and in practice. They are the basis for the development of flowcharts, list of client needs, alternative process routes, outsourcing, training, etc., which helps the manager understand the entire organization and detect any distortions in the goals laid down at the strategic level and in the business plan. After mapping all this issues out, a survey of all of the clients' needs is conducted and plans are made to improve the efficiency of the company as a whole by breaking barriers between areas, eliminating closed informal groups and promoting integration.

Therefore, the model of Process Management that is being suggested in this paper will deal with the activities concerning the development of a Robust Design as a chain of clients, processors and suppliers. Each group of people involved in this chain must be aware of his/her importance to the final output and, in order for this to occur, must carry out his/her activities and deliver a product or service that meets the needs of subsequent processors.

This concept will be coupled with the Taguchi Method, in order to attain the integration between the design group and the company sectors from which the team will gather the data for conducting the experiments. Data acquisition based on the knowledge accumulated by the people must reach the planning phase of such experiments as reliably as possible, in order to achieve the required reliability. It is expected that Process Management applied to the Taguchi Method will decrease the risk of distortion and encourage the dissemination of its philosophy among the people involved.

3. THE PRINCIPLE OF THE TAGUCHI METHOD

Since the statistical details of the Taguchi concepts are out of the scope of this paper, just an overview will be provided for better understanding the stages suggested.

Taguchi deals with the quality of the engineering design (off-line) as well as with the quality of manufacturing (on-line). His ideas can be divided into two basic principles. Firstly, quality losses increase as deviations from target occur, instead of announcing zero failure until arbitrary control limits are exceeded (such as in Statistical Process Control). The *loss function* quantifies this "loss for society".

The second principle is the achievement of high quality through the design of the manufacturing process, which also makes the Taguchi method distant from the Statistical Process Control. Quality is designed, not manufactured in the product.

Loss function. The very core of Taguchi philosophy is the *quality loss function*. Taguchi defines the cost of low quality as being the losses that a given product impose to society from

the moment this product is sold. This definition also contributes to detach the Taguchi method from the traditional Statistical Process Control approach which defines the cost of quality as the cost of waste, rework and technical assistance. According to Taguchi, any deviation from target reduces the value of products for society.

Quality by design. Taguchi requires a robust design in order to control variability both in purchase and in manufacturing, production and end use. Instead of the tight CEP control limits (which increase production costs) to ensure nominal performance, Taguchi argues in favor of product design in order to achieve *nominal performance*, even though there is variability in the production and in the end use conditions.

Taguchi divides the design process into two clear-cut phases:

- **system design**, in which engineering concepts are spelled out. This system design is concerned with the achievement of quality at reasonable costs in order to be competitive in the market. In this phase, the Taguchi method offers little help;
- **parameters design**, in which nominal design values are set. The *design by tolerance* is the setting of design tolerances in industrial manufacturing. In the *design by parameters* and *design by tolerance*, the Taguchi method offers suggestions to assist in the design quality of the product.

Design phases are harmoniously interconnected, thus creating the simultaneous engineering of both the product and the manufacturing process.

Reduction in the number of factors and levels. When analyzing the quality characteristics that may impact products or processes, it is quite common to find ten or more variables, present in two or more levels to be assessed, which would require at least $2^{10} = 1024$ experiments to determine which of these characteristics are really significant. Considering the costs and time spent in some tests, covering all combinations is sometimes prohibitively expensive. Traditional statistics proposes the utilization of the knowledge of the technical staff to rule out some unnecessary combinations, and works with the so-called *fractional factorial design*.

The design proposed by the Taguchi method is an outline of the fractional factorial model. He also developed the so-called *linear graphs* and *orthogonal arrays* as tools that help bring experimental statistics and the daily lives of engineers closer together.

The principal difference between classical experiment design and the Taguchi method is response selection. The former considers this selection as an activity outside its range of action, leaving it to the professionals dealing with the problem. The latter, Robust Design, requires a detailed engineering analysis in order to choose the quality features and to determine the signal-noise ratio. Phadke (1989) quotes the following: “selecting the quality features and test conditions for evaluating the sensitivity of noise factors, of the signal-noise ratio and control factors is a difficult and time-consuming task during the planning of the Robust Design. A good engineering know-how about the specific design and also knowledge about the Robust Design are required.”

Therefore, the people involved in the activities related to the development of the Robust Design must supply the design staff with as much input as possible, so that a perfect integration between engineers and Taguchi method experts can take place. Process Management will make people interact, thus disseminating the Taguchi method within the organization and speeding up the conclusion of studies.

The practical use of the concepts described above and all aspects involved is the starting-point for Process Management.

4. THE APPLICATION OF PROCESS MANAGEMENT TO SUPPORT THE TAGUCHI METHOD

Depending on the cultural aspects that involve the design team, the application of Process Management will cause differences in the degree of detail of the activities and formality of documents. The principal issue here is meeting the needs of both internal and external clients.

As an example, stages suggested by Pedroso (1996) were used for application of the Taguchi method. Figure 4 shows a PERT diagram of the activities placed in such a way that the outputs of each activity are the inputs of the subsequent activities. The question “why?” made to a given activity must be answered in a coherent way by the activity to the right. From right to left, the question “how?” must be fulfilled. This is a way of ensuring the actual need for activities, although different teams may create diagrams that have their own peculiarities.

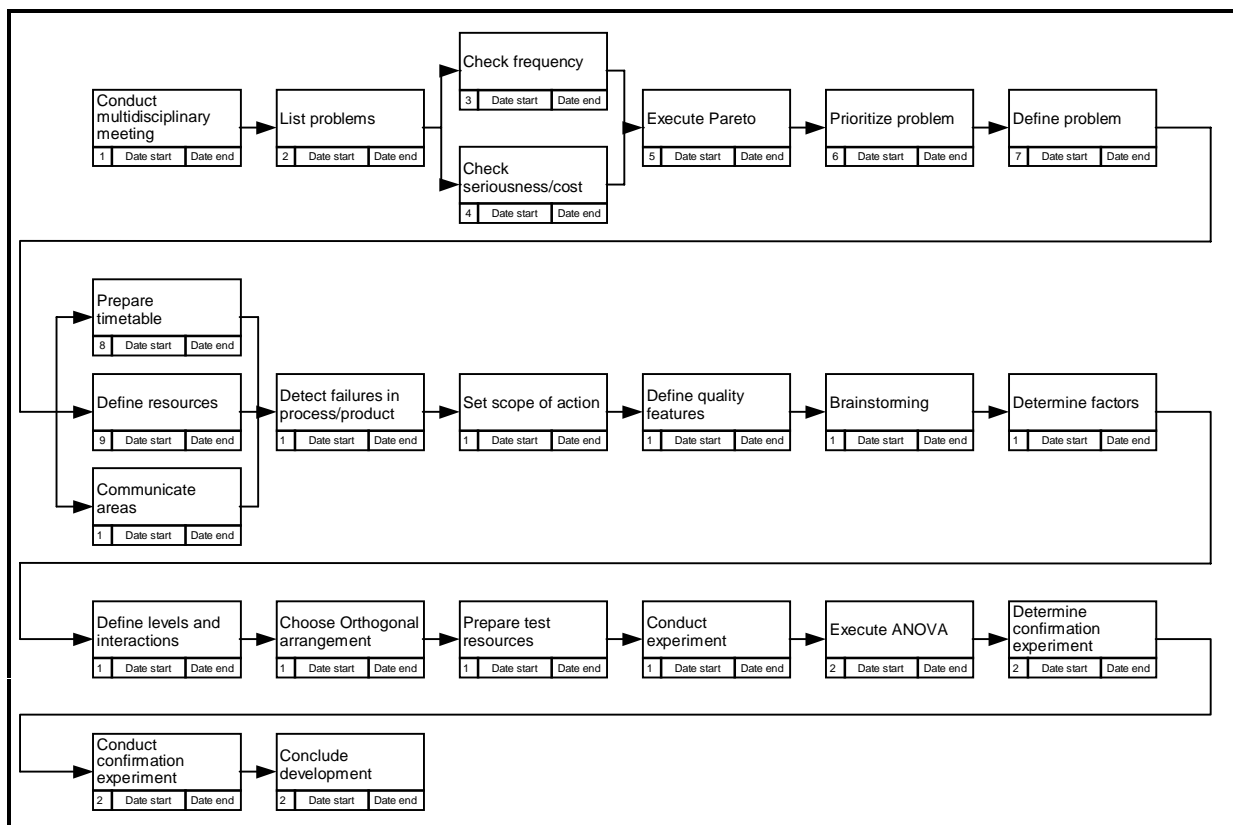


Figure 4 - PERT Diagram of the activities required to develop the Robust Design.

Source: Pedroso (1996).

Each activity can be isolated, and its full description will ensure that the people assigned to perform it actually do so, regardless of having participated in the previous activity. A form containing the description of the results, activities, input, team and time will make the process more dynamic. Figure 5 shows an example of form used in Process Management that can be adapted to conduct the Taguchi method. Its benefit is in summarizing all of the activities and in clearly identifying the internal needs. Another graph with all the details of each activity can be prepared and forwarded to the team members.

We must bear in mind that Process Management involves a multidisciplinary staff and, therefore, training meetings must be conducted prior to its application, until all people involved are aware of the goal of this methodology.

By following the proposed schedule and by gathering the outputs as they are completed, we can safely conclude the design (robust design). A similar diagram can be conducted in parallel, in which the managerial activities that are necessary for the communication of the people responsible for the tasks, group organization, grouping of forms and report editing are dealt with.

Activity breakdown				
Activity	Results	Client output	Client requirements	Inputs
Comp.:				
Comp.:				
Comp.:				
Comp.:				

Figure 5 - Example of spreadsheet used for the activity breakdown.

As the design team gathers the outputs we can easily prepare a data bank by using filled out forms. The use of these forms, coupled with other methodologies enabling the simultaneous engineering of both product and process will speed up the design process. In addition, as more people engage in the execution of the robust design, they gain a better understanding about the product that is manufactured by the company, which occurs in a similar way in methodologies such as the Quality Function Deployment (QFD) or the Function Analysis System Technique (FAST diagram), in addition to disseminating the Taguchi philosophy, which is one of the factors responsible for Japan’s success in quality issues.

Process Management does not stop there. A mapping of activities is carried out in an early stage, but a constant analysis must be carried out to check for improvements in the meeting of needs. At all times, each participant in the chain has the chance to make suggestions: it is an on-going improvement procedure.

5. CONCLUSIONS

This article proposed a specific application of Process Management: the preparation of experiment designs by using the Taguchi method. The great benefit obtained is the engagement of the design team members and of other areas towards the achievement of a common goal, instead of assigning this responsibility to just a few experiment experts. This

encourages more participation, thus promoting the sharing of knowledge about product and process held by the technical staff, which can be used more intensely in the experiment design, aiming at quality improvement.

On the other hand, engaging more people in the Robust Design allows them to acquire a deeper understanding about the company's product and process, in addition to disseminating the *off-line quality* philosophy successfully applied by the Japanese and by numerous occidental companies.

REFERENCES

- Fiod Neto, M., 1997, Taguchi e a melhoria da qualidade: uma releitura crítica, Editora da Universidade Federal de Santa Catarina, Florianópolis, Brasil.
- Juran, J. M., 1992, A qualidade desde o projeto - novos passos para o planejamento da qualidade em produtos e serviços. Pioneira, São Paulo, Brasil.
- Harrington, J., 1993, Aperfeiçoando processos empresariais, Makron Books, São Paulo, Brasil.
- Hendrix, C. D., 1990, What every technologist should know about experimental design, ChemTech, mar., pp. 1-28.
- Ostrenga, M., Ozan, T. R., McIlhattan, R. D. and Harwood, M. D., 1993, Guia Ernst & Young para gestão total dos custos, Record, Rio de Janeiro, Brasil.
- Pedroso, D. M. W., 1996, Qualidade em serviços: uma proposta de determinação de parâmetros mediante o método de Taguchi, Ph.D. Thesis, Universidade Federal de Santa Catarina, Florianópolis, Santa Catarina, Brasil.
- Phadke, M. S., 1989, Quality engineering using robust design, Prentice Hall & AT&T, New Jersey.
- Ryan, T. P., 1988, Statistical methods for quality improvements. University of Iowa, Iowa.