Manufacturing processes coursework

Question IV

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Question 4 (i)

1. 1 Introduction

We consider quality as a goal in the manufacturing of a product. First it is important to define what is understood by quality. Quality is often considered as 'something that is well done, something that doesn't break'. However the 1 million dollars McLaren F1 is useless take your 5 children to school. Therefore we define quality as *fitness for intended purpose*. I.e. the McLaren is and excellent quality product because it is the best in what is supposed to do, but the Ford Galaxy is also good because it also fits its purpose. Quality is defined in ISO 8402 as *"the totally of features and characteristics of a product or service that bear on its ability to satisfy a given need"*. Obviously 'not breaking' is often one of the purposes of a product and therefore it part of the quality.

1.2. Taguchi Method

It is being increasingly recognized that the high quality of a product or service and the associated customer satisfaction are the key for enterprise survival. Also recognized is the fact that pre-production experiments, assuming properly designed and analyzed, can contribute significantly towards quality improvements of a product. A traditional (but still very popular) method of improving the quality of a product is the method of adjusting one factor at a time during pre-production experimentation. In this method, the engineer observes the result of an experiment after changing the setting of only one factor (parameter). This method has the major disadvantages of being very costly and unreliable. The Japanese were the first to realize the potential of another method using statistical design of experiments (*SDE*) - originally developed by R. Fisher . *SDE*, in contrast to the one factor method, advocates the changing of many factors simultaneously in a systematic way (ensuring an independent study of the product factors). In either method, once factors have been adequately characterized, steps are taken to control the production process so that causes of poor quality in a product are minimized.

Taguchi methods were developed by Genichi Taguchi to improve the implementation of total quality control in Japan. Taguchi methods are claimed to have provided as much as 80% of Japanese quality gains. This is no small feat considering that Japanese quality gains have brought a large number of industries in the USA to their knees[1]. They are based on the design of experiments to provide near optimal quality characteristics for a specific objective. Unfortunately, most of those who demean Taguchi methods have missed the whole point. Taguchi methods are not just a statistical application of design of experiments. Taguchi methods include the integration of statistical design of experiments into a powerful engineering process.

[1] (Dertouzos, Lester, and Solow, 1989).

The true power of Taguchi methods comes from their simplicity of implementation. They are often applied on the Japanese manufacturing floor by the technicians to improve their product and their processes. The goal is not just to optimize an arbitrary objective function, as they are so often used in the west.

A different method of measuring quality is central to Taguchi's approach to design. Loss function measures quality. The loss function establishes a financial measure of the user dissatisfaction with a product's performance as it deviates from a target value. Thus, both average performance and variation are critical measures of quality. Selecting a product design or a manufacturing process that is insensitive to uncontrolled sources of variation improves quality. Taguchi calls these uncontrolled sources of variation *noise factors*. This term comes from early applications of his methods in the telecommunications industry.

The goal is to reduce the sensitivity of engineering designs to these *noise factors*. The objective function used is the signal to noise ratio which is maximized. This moves design targets toward the middle of the design space so that external variation effects the behavior of the design as little as possible.

The five major points of the Taguchi quality philosophy are:

1.In a competitive market environment, continual quality improvements and cost reductions are necessary for business survival.

2. An important measurement of the quality of a manufactured product is the total loss generated by that product to the society.

3. Change the pre-production experimental procedure from varying one factor at a time to varying many factors simultaneously (SDE), so that quality can be built into the product and the process.

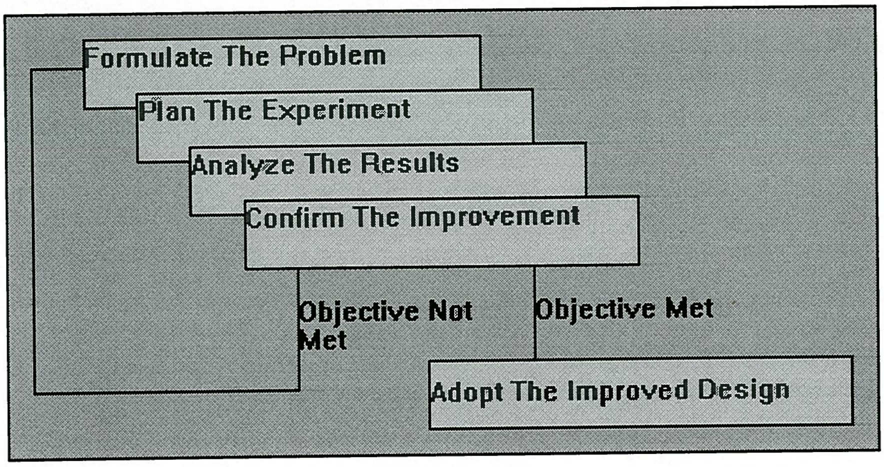
4. The customer's loss due to poor quality is approximately proportional to the square of the deviation of the performance characteristic from its target or nominal value. Taguchi changes the objectives of the experiments and the definition of quality from "achieving conformance to specifications" to "achieving the target and minimizing the variability.

5. A product (or service) performance variation can be reduced by examining the non-linear effects of factors (parameters) on the performance characteristics. Any deviation from a target leads to poor quality.

Essentially, the central idea Taguchi's design is that variations in a product's performance can inevitably result in poor quality and monetary losses during the product's life span. The sources of these variations can directly be classified into the two categories of controllable and uncontrollable or noise parameters.

For instance, in a typical design application, factors such as geometric dimensions of a part can easily be controlled by designers. Uncontrollable or noise factors such as environmental variables, product deterioration or manufacturing imperfections, on the other hand, are also sources of variations whose effects can not be eliminated. Therefore, RD's main function is to reduce a product's variation by reducing the sensitivity of the product to the sources of variation rather than by controlling these sources. In other words, RD reduces response variation by selecting appropriate settings for controllable parameters as to dampen the effects of hard-to-control noise variables. This is the crux of off-line quality control .

Taguchi's Methodology for implementing robust design is essentially a four step procedure which can best be illustrated as follows:



How to Measure Quality

Traditionally, quality is viewed as a step function as shown by the heavy line graph in the figure 1. A product is either good or bad. This view assumes a product is uniformly good between the specifications (LS the lower specification and US the upper specification). The vertical axis represents the degree of displeasure the customer has with the product's performance. Curves A and B represent the frequencies of performance of two designs during a certain time period. B has a higher fraction of "bad" performance and therefore is less desirable than A.

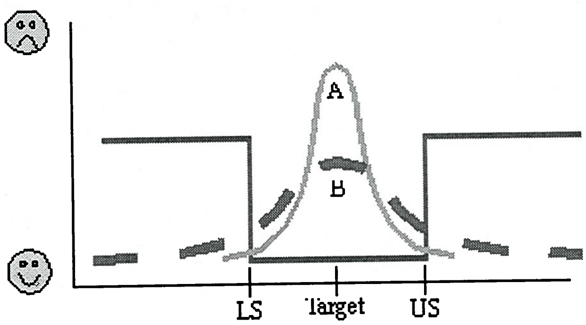


figure 1

Sometimes traditional decision makers and those using Taguchi's loss function will make the same judgments. If organizations consider both the position of the average and the variance, and if the averages are equal and/or the variances are equal, then the traditional decision maker and one using Taguchi's loss function will make the same decision. However, the traditional decision-maker calculates the percent defective over time when both the average and variance are different.

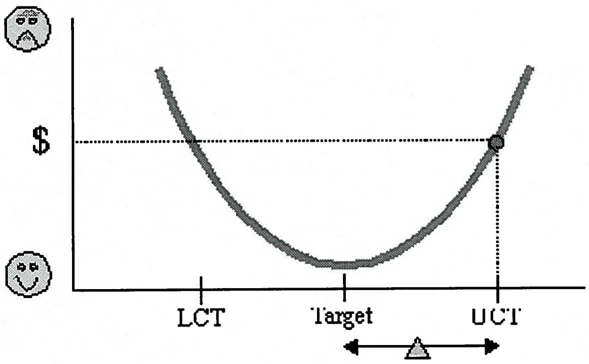


figure 2

Taguchi believes that the customer becomes **increasingly** dissatisfied as performance departs farther away from the target.
He suggests a quadratic curve to represent a customer's dissatisfaction with a product's performance. The quadratic curve is the first term when the first derivative of a Taylor Series expansion about the target is set equal to zero. The curve is centered on the target value, which provides the best performance in the eyes of the customer. Identifying the best value is not an easy task. Targets are sometimes the designer's best guess.
LCT represents lower consumer tolerance and UCT represents upper consumer tolerance. This is a customer- driven design rather than an engineers specification. Experts often define the consumer tolerance as the performance level where 50% of the consumers are dissatisfied. Your organization's particular circumstance will shape how you define consumer tolerance for a product.
The equation for the target-is-best loss function uses both the average and the variance for selecting the best design. The equation for average loss is:

$$\overline{\text{Loss}} = k\left\{\sigma^2 + (\bar{y} - T)^2\right\} \text{ where } k = \frac{\$}{\Delta^2}$$

Calculating the average loss permits a design team to consider the cost benefit analysis of alternate designs with different costs yielding different average losses. As seen in figure 2, there is some financial loss incurred at the upper consumer tolerance. This could be a warranty charge to the organization or a repair expense.
Most applications of the loss function in QFD can use a value of 1 for k since the constant would be the same for all competitors as it relates to the customer.
The graphics show a symmetric loss about the target, but this is not always the case.
If two products have the same variance but different averages, then the product with the average that is closer to the target (A) has better quality figure 3.

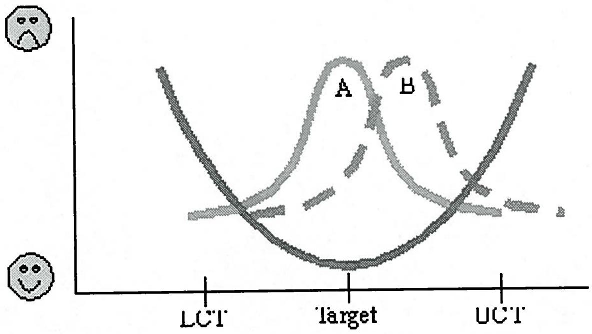


figure 3

If two products have the same average but different variance, then the product with the smaller variance has better quality figure 4. Product B performs near target less often than its competitor.

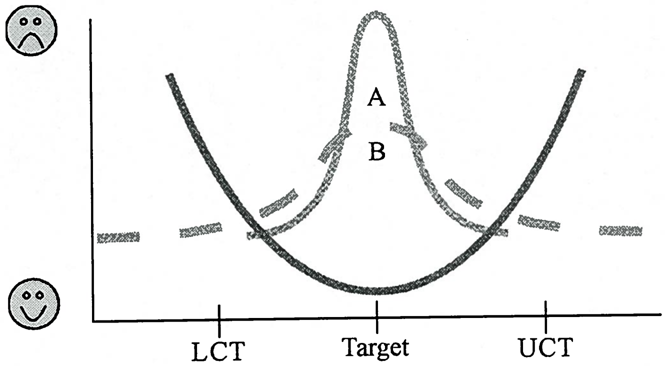


figure 4

What if both average and variance are different? Calculating the average loss assumes you agree with the concept of the loss function. The product with smaller loss has the better quality figure 5. If curve A is far to the right, then curve B would be the better. If curve A is centered on the target, then curve A would be better. Somewhere in between, both have the same loss.

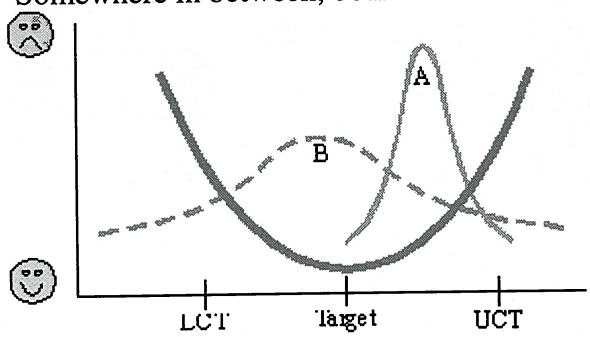


figure 5

Loss Function and Technical Bench Marking

Teams should gather data collected for technical bench marking in a real environment. A real environment is one in which everything is not controlled and ideal. Our product and the competitor's product would be evaluated at different temperatures, humidity and other conditions. The laboratory can simulate these conditions. By evaluating the product's performance in several environmental conditions, you would have realistic data to calculate the real world variance.

An orthogonal array can define a balanced study of different environmental conditions. The two or three important environmental conditions, each at two levels, provide a good estimate of the environmental variation. The humidity is represented by H, the weight of items taped to the sheet on the wall by W, and the surface texture by T. The 1 and 2 under H represent high and low humidity. The four different combinations of environments are used to determine the average and variance of each product's performance.

H	W	T
1	1	1
1	1	2
1	2	1
1	2	2
2	1	1
2	1	2
2	2	1
2	2	2

Environment	H	W	T
1	1	1	1
2	1	2	2
3	2	1	2
4	2	2	1

Instead of using all eight different combinations, the orthogonal array uses a special subset of the eight. Due to the balanced nature of these four combinations, the effect of the missing four can be predicted.

Another option is to select the best and the worst environmental combination of the eight combinations. This approach further reduces the number of environments evaluated to two.

The average loss for the data is:

$$\text{Loss} = k\frac{1}{n}\sum_{j=1}^{n}(y-T)^2 \quad \text{where } k = \frac{\$}{\Delta^2}$$

The calculations of the variance and loss can be entered in two additional rows at the bottom of the Demanded Quality vs. Performance matrix used in QFD. The ratio of the average loss of one competitor to another is independent of k. The information of the average, variance and loss ratio identifies the directions for improvement as defined by the average loss equation.

1.3 ISO 9000

ISO stands for International Organization for Standardization, which is a special agency for standardization. ISO was formed by the national standards organizations of over 90 countries in order to facilitate the international commerce of goods. ISO 9000 was first issued in 1987 and by 1993 fifty countries had accepted it as their national standards.

Today, ISO 9000 certification is rapidly becoming a competitive factor. The impetus for ISO certification in the USA came from the desire to sell products in Europe, which has been the forerunner in requiring ISO 9000 certification for suppliers. However, it is becoming the standard internationally. Even NASA has adopted ISO 9000 as the basis for it's quality system and the quality systems of it's suppliers.[1]

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[1] A list of all the companies registered for ISO 9000 can be found at http://www.qualitydigest.com/html/iso9000.html or http://www.iso9000directory.com/search.htm

ISO 9000 has three different certificates:

ISO 9001	Model for quality assurance in design, development, production, installation and servicing
ISO 9002	Model for quality assurance in production, installation and servicing
ISO 9003	* (less comprehensive) = Model for quality assurance in final inspection and test.
ISO 9004	Quality management and quality systems elements, *guideline.*

Companies usually don't register for the 3 of them. A company will normally choose one or two depending on its needs. The typical registrations are 9001 and 9002, sometimes 9003, however 9004 is just a guideline and it is not possible to register for it. The choice of which model to implement depends on the company's operation. For example, a company that has its own product or service must consider ISO 9001. If it only manufactures (working off someone else's design) it may wish to consider ISO 9002. Finally, if it neither designs nor manufactures, it may wish to consider ISO 9003. There are also documents on guidelines for implementing ISO 9001, 9002, and 9003; project management; process industries; configuration management; quality plans; quality manuals; economics of quality; and continuous improvement.
ISO 9000 generic and can be applied in any industry, however for Electrical Engineering there is the IEC (international electrotechnical commission) that complements itself with ISO.

Critics

I think that it important to point out that the are critics to this quality assurance methods, Morup (1992) notes that "*It has become good business to promote and sell ISO 9000 certification as the way to join the quality bandwagon. However, certification appears to us to be nothing more than a craze, which is only able to help those companies that have poor quality control. It is just a matter of time before certification is no longer a competitive factor.*
In fact, many companies have characterized ISO 9000 as several steps backward from where their total quality management systems are today. Instead of believing that we can ensure the quality of our products by focusing on certificates and on the quality of our control systems, we should rather concentrate on the fact that quality in the final analysis needs to be designed into the product"

1.4. Application to Aircraft Industry

In aircraft industry it is especially important to set quality standards like the ISO 9000. This is due to the extremely negative consequences that deficiencies can cause. If two DC-9's crash in one month killing 100 people everybody (airlines, passengers...) is going to consider that it is a bad aircraft, however if 100 Ford Mondeos crash in the same period of time killing twice as many people the public opinion won't provably even know. This proves the importance of customer dissatisfaction in the aircraft business and the importance of applying Taguchi's methods to it. We must remember that if quality is defined as *'fit to purpose'* then for the aircraft industry one of the main purposes it to be extremely safe and not to crash.
As nowadays parts for one aircraft model are manufactured in different and distant parts of the world, an international standard for quality as the ISO 9000 is very desirable. A good example are Airbus aircraft which are manufactured mainly by the four main partners in 4 different countries, but many parts are also built in the USA and Asia, also parts for the Boeing aircraft are built in Europe. Having common quality standards allows, for example that when part of the fuselage of the 737 gets to Seattle from Italy for final assembly, people there know that the accomplish the same quality standards as they have.
It is important to remember that methods to improve quality such as the ISO 9000 standards and Taguchi methods are more successful is they are applied together.

Question 4 (ii)

2.1 Introduction

Just-in-time and Total quality are replacing the old methods of production in which waste a permissible and usually the norm. The accent now is on flexibility, and process layouts are being replaced by and flow lines manufacturing production families. Shorter production runs and fast changeovers are also required, with maintenance now being more important than even before

2.2 Just-in-Time (JIT)

Just in time (JIT) has its origins in the Toyota Company in Japan. In the 1960s, Toyota worked hard on developing a whole range of new approaches to managing manufacture. The development of these approaches was hastened by the 'oil stock' of the 1960s. By 1972 these new approaches had begun to attract wide attention in Japan and in the mid 1970s other Japanese companies begun to experiment with and adopt these approaches. This stage and for some time later these were not known as JIT , but as 'Toyota manufacturing System'. By the end of the 1970s this system had begun to attract the attention of the West.

One of the many elements of this system was a pull scheduling technique using 'kanbans' (Japanese for cards). The system first became known in the West as 'The Kanban system'. This was rather misleading, as Kanban is only a small part of the total system, and very difficult to operate independently of a large set of other activities.
Just in time management is not one technique or even a set of techniques for manufacturing, but it is an overall approach or philosophy which embraces both old and new techniques.
Just in time is a disciplinated approach to improving overall productivity and eliminating waste. It provides a cost-effective production and delivery of only the necessary quantity of parts at the right quality, at the right time and place, while using the minimum amount of facilities, equipment and human resources[1].

The JIT idea is simple: Produce and deliver finished goods just in time to be sold, subassemblies just in time to be assembled into finished goods, fabricated parts just in time to go into subassemblies, and purchased materials jut in time to be transformed into fabricated parts. Somebody said "*Japanese Industry produces small qualities just in time; Western industry produces massive quantities just in case*"[2]
JIT can be divided into seven elements. There are six different internally focused elements and one externally focused element. The first internally focused element is the just-in-time philosophy itself, the elimination of waste. The second is the quality at the source. There are three engineering elements: uniform plant load, overlapping operations (machine cells or group technology), and a minimum setup time. The six sixth internally focused element is a type of control systems called pull system or *Kanban*.

[1] From C.A. Voss. "Just in Time Manufacture"
[2] From "Japanese Manufacturing techniques, nine hidden lessons in simplicity" Richard J. Schonberger.

The zero inventory system of JIT has also its risks or inconvenients; for example a strike in of a transport company or a subcontractor can seriously affect your production. This was widely felt in the USA during the UPS strike last year, another example happen in May 1998 when the Swedish car company Saab had to stop production due to a strike of one of its Danish subcontractors. I think that aerospace industry will be less affected by this kind of problems as production takes a long time and in general in small quantities. This would allow for a company to 'catch up' in the dead lines if necessary after a storage of supplies and it won't probably make to much difference for an airline to wait just a few more days for an aircraft delivery and

2.3 Total quality control (TQC)

The goal of total quality control (TQC) is to sustain the habit of quality improvement, while the target is simply perfection.

Total quality control and JIT are two concepts that should ideally be applied together In a Total Quality/Just-in-time environment to obtain maximum performance.

JIT contributions to TQC are:

- Immediate feed back
- Slower run speeds
- Stopping the process

2.4 Zero defects (ZD)

'Zero defects' is not the same as total quality control although it is very often confused with it. A popular ZD slogan is "*quality is everybody's business*". A zero defects approach simply doesn't accept that there is going to be a percentage of defects in the manufactured goods and tries to get 'zero defects'.

2.5 Right first time (RFT)

The idea of RFT is to control the process instead of controlling the product, this is much easier (and cheaper) than check the quality of every item manufactured (may be 2,000 cars or 2,000,000 of pieces).

2.6 Lean production

The aim of lean production is to continuously improve effectiveness and efficiency. Agile manufacturing is the name given to lean production once applied. The basic characteristic of lean production is flexibility. Flexibility is very important nowadays due to the need to respond quickly to the customer needs.

2.7 Application to Aerospace Industry

Systems such as Just in Time, Right the First Time and total Quality Control are extremely important for the Aerospace industry. This industry has to adapt itself very quickly to the changing market. For example a economic crisis in Asia may made the orders fall drastically for a period of one or two years or there may be a oil crisis that make airlines loss profits. The problem with storage is even worst in the aerospace industries than in many others as parts are extremely expensive and sometimes big and delicate, for example composites that can start delaminating if they are hit by a spanner or something similar. There are also a huge number of parts in each aircraft. It is very expensive to store all this parts. JIT solves this problem as it allows the flexibility the industry needs to adapt itself to the changing economic situation of the world and also allows to save costs in storage.

Right the first time is also extremely important for the aerospace industry. The extremely large number of different pieces that form an aircraft makes it extremely difficult to inspect them one by one, RFT solves this problem.

Defects in Aerospace are very undesirable due to the potential risk of human life and huge amount of money, prestige…Therefore having a total quality approach and a zero defects policy is vital.

All these methods (JIT, TQC, RFT, Lean production…) work better if used together, they never contradict each other and they are very synergetic. Some of them even need of the others in order to be successful. Some of the real power of these methods comes from their interaction with each other.

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