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INFLUENCE OF VARIABILITY ON A RELIABLE PRODUCTION PROCESS

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Abstract: *In this article the influence of variability on a reliable production process is considered. Variability itself is a natural part of any process however if characteristics of variability are not stable and increase time to time so this is a problem to work on. In case variability comes out of the allowed borders the production process becomes unreliable. This process leads to degradation of main production process characteristics: time of production output and product's quality. Therefore it is highly advisable to track process variability and control it. In order to do this one of the best analysis to use is Statistical Process Control (SPC), which allows to reveal hidden problems in process and determining causes of these problems before a failure occurs.*
Keywords: *Reliable production process; Variability; Performance; SPC*

1. INTRODUCTION

In today's competitive environment, markets are becoming more international, dynamic, and customer-driven. Customers are demanding better reliability and faster delivery. There are a number of reasons why reliability is an important product attribute, including: reputation, customer satisfaction, warranty costs, competitive advantage and so on. Classical definition of reliability is: reliability is the probability that an item can perform its intended function for a specified interval under stated conditions (Military Handbook, 1998). Even though a product has a reliable design, when the product is used in the field, its reliability may be unsatisfactory. The reason for this low reliability may be an unreliable manufacturing process. If we look back at the definition of reliability it can be said that in terms of a production process the definition means that a reliable production process must fulfill its function or in other words produce qualified products in required time. In case one of these two characteristics does not fulfil the requirements the production process becomes unreliable. Unreliable production processes waste money. Few companies know or measure the reliability of their processes. All unmeasured processes are verbalized as reliable. This fantasy continues until the process is measured. Most processes are unreliable and thus need improvements (http://www.barringer1.com).
There are number of methods to evaluate and improve process reliability, for instance, PFMEA, FTA, RBD, however in this paper the question of the process reliability will be evaluated from the aspect of production process variability.

2. VARIABILITY AND PERFORMANCE

In manufacturing systems, almost all attributes are of interest to variability. To effectively analyze variability, it must be estimated. It is achieved by using standard measures.
A relative measure of the variability of a random variable is the standard deviation divided by the mean, which is called the coefficient of variation. If we let t denote the mean and σ denote the variance, the coefficient of variation C can be written

$$C = \frac{\sigma}{t} \quad (1)$$

According to this coefficient the variability is divided into three categories:

- $C < 0{,}75$ low variability,
- $0{,}75 < C < 1{,}33$ - average variability,
- $C > 1{,}33$ high variability (Koszkul et al.,2006)

To identify strategies for managing production systems in the face of variability, it is important to understand the causes of variability. The most prevalent sources of variability are:

- "Natural" variability
- Random outages
- Recycle

The definition of "natural" variability shows itself that this is a normal part of a process and thus it cannot be eliminated at all.
Random outages or breakdowns are the causes of the largest variability in many systems.
Variability from recycle happens when a workstation performs a task and then checks to see whether the task was done correctly. If it was not, the task is repeated (Hopp & Spearman, 2001).
As it can be seen failures of both characteristics of reliable production process, quality and time, are direct causes of variability in the process. Quality is already named like one of the causes, as for time - all breakdowns in the process lead to decreasing of process performance.
As process times and quality measures are the characteristics which are affected by variability, thus it can be said that performance of the production process is affected by the variability as these characteristics are components of performance. Certainly, there are also others components like utilization, work in process, cycle time and so on, however, in the frame of this article they are not taken into consideration.
Main characteristic of process time is throughput. The throughput is defined like the average quality of good parts produced per unit time.
Talking about good part is always meant quality of this part. Inspection of quality, as usually, refers to a finished part. However the best way to think about quality is in process control. If the process is under control, inspection is not necessary (Hopp & Spearman, 2001).
Quality control is a single link in the total reliability process. No product can perform reliably without the inputs of quality control because quality parts and components are needed to go into the product so that its reliability is assured (http://www.weibull.com).
There are several problems with inspection under traditional quality control:

1. The inspection process does not add any "value"
2. Inspection is costly
3. It is sometimes done too late in the production process. This often results in defective or non-acceptable goods actually being received by the customer

Taking into consideration all these factors it can be said that such a method like SPC is very suitable for the process tacking.

3. STATISTICAL PROCESS CONTROL

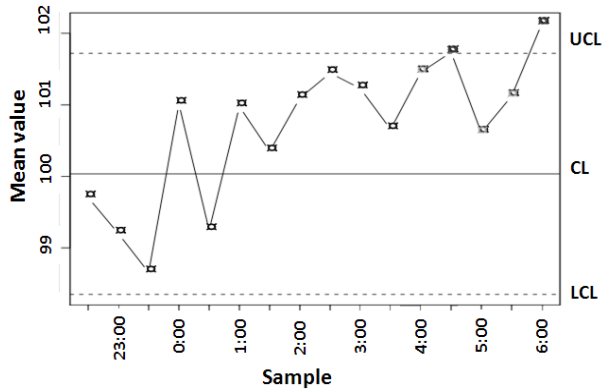

Fig. 1. An example of control chart

Statistical process control (SPC) is the application of statistical methods to the monitoring and control of a process to ensure that it operates at its full potential to produce conforming product. Under SPC, a process behaves predictably to produce as much conforming product as possible with the least possible waste.

Much of the power of SPC lies in the ability to examine a process and the sources of variation in that process using tools that give weight to objective analysis over subjective opinions. Variations in the process can be detected and corrected, thus reducing waste as well as the likelihood that problems will be passed on to the customer. With its emphasis on early detection and prevention of problems, SPC has a distinct advantage over other quality methods, such as inspection, that apply resources to detecting and correcting problems after they have occurred.

SPC may be broadly broken down into three sets of activities: understanding the process; understanding the causes of variation; and elimination of the sources of special cause variation.

In understanding a process, the process is typically mapped out and the process is monitored using control charts (figure 1).

When, through the control charts, variation that is due to special causes is identified, additional effort is exerted to determine causes of that variance and eliminate it (Oakland, 2008).

4. CASE STYDY

A case study was carried out for a screw driver. Initially there was a pneumatic screwdriver installed. The process of screws tightening was unreliable (figure 2). After the SPC analysis was done and the results were presented graphically (Laaneots & Mathiesen, 2006), it was decided that a root ca use of the process variability is the pneumatic screwdriver itself. Thus it was decided to change the screwdriver for an electric. The analogous SPC analysis was

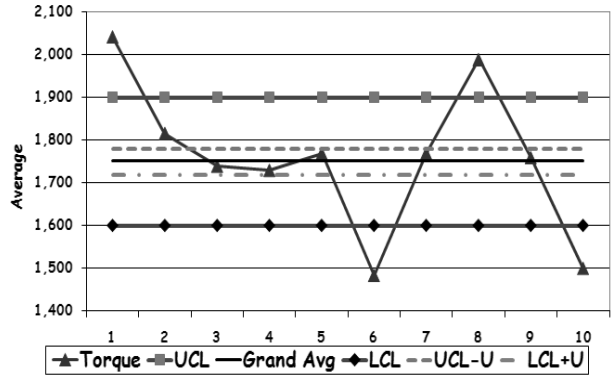

Fig. 2. SPC analysis for the pneumatic screwdriver

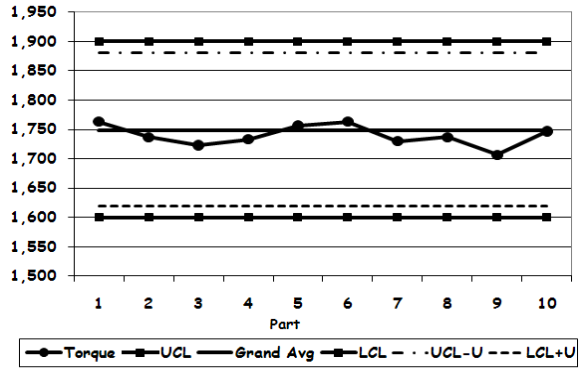

Fig. 3. SPC analysis for the electric screwdriver

carried out for the new screwdriver which showed that the process became stable and its variability was very low (figure 3).

The coefficient of variation was calculated according to equation (2):

$$C = \frac{0{,}034}{1{,}74} = 0{,}02 \qquad (2)$$

Which is according to Hopp and Spearman is low variability.

The result of the analysis shows that at the moment the process of tightening the screws is very stable and reliable. However the variability may increase in case of, for instance, defected components or screwdriver's failure.

Thus, it is recommended to track the process further using the same SPC analysis. More over the analysis can be improved by adding the reaction limits to the graph. The reaction limits help to detect a problem in the process at the earlier stages. If the graph of the process crosses the reaction limit, it is a sign for management to pay attention to the process and implement the reaction actions before a failure in the process occurs.

5. CONCLUSION

In the article the problem of variability's influence on a production process is discussed. The production process becomes unstable and unreliable in case of high variability in it. The SPC analysis is offered like one of the best methods for tracking of the process variability. This method allows not only tracking of variability level in the process, but also to prevent problems with quality, which lead to failures in production process. In addition the using of the SPC method allows to reduce or eliminate additional control of the final product what considerably saves time and resources of a firm.

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