

20

USE OF SIX SIGMA IN THE PRODUCTION PROCESS – CASE STUDY

20.1 INTRODUCTION

Statistical quality control methods are used primarily in companies which specialise in high-series and mass production. Implementing such control is relatively inexpensive, which is why these methods are so commonly utilised. Statistical control is one of the more effective quality management methods. As a result of work started by Shewhart, Deming, Ishikawa and Toguchi, many tools for process control have been created, such as: TQM, Six Sigma and Shainin Tool. Each of these methods has its own assumptions regarding base values and the way in which the goal is to be achieved, depending on the method, different departments of the company are engaged and a varying level of knowledge and expertise required in order to implement the selected solution. Six Sigma is a method of quality management implemented at Motorola in the mid-1980s by Bob Galvin and Bill Smith. In mathematics, Six Sigma denotes standard deviation. It refers to the six standard deviations' distance from the central value of normal distribution in both directions. The range of six sigma, left and right, from the arithmetic mean in a normal distribution demarcates the area outside which there is a 3-4 in a million probability of occurrence. In the Six Sigma method it is assumed that defects in processes occur with a certain probability, which can be described using statistical distributions. The business goal at the Six Sigma level is, therefore, to lower the probability of a defect occurring to 3-4 in a million. This way the Six Sigma approach can lead to an increase in quality and process reproducibility [6].

20.2 THE SIX SIGMA METHOD

The Six Sigma method has been developed with the purpose of preventing problems on the client's end in mind. Applying this methodology, the company wants to be perceived as proactive, fast and efficient by the client, an expert in its field, launching new processes seamlessly.

The Six Sigma method is a process which focuses on processes based on data. It is a philosophy centred on the continuous improvement of processes. It helps to minimise the sources of variability, define and solve problems, design new products

achieving “defect free quality levels”. Six Sigma helps to set the direction the company should take in order to improve its results [1, 2, 6].

The aim of the Six Sigma method is a reduction of variability so that the value of σ is within the specification limits. The value of sigma in specification limits shows the number of defects (DPM – defects per million).

The basis of the Six Sigma method are data and the assumption that every process fits the equation $y = f(x_1, x_2, \dots, x_n) \rightarrow$ where Y is a dependent variable, output, effect, symptom, monitoring, and X is an independent variable, process input, cause, problem, control. The key to the Six Sigma concept is the focus on Xs or the problems. Due to the limitations arising from the nature of this article, more on the methodology of Six Sigma can be found in [4, 5, 6, 7].

20.3 USE OF SIX SIGMA IN THE INDUSTRY

The article presents the use of the Six Sigma method in a company which manufactures electrical power steering systems for passenger cars.

The problem investigated in the present article is one of the operations on the semi-automatic production line. The station performs a measurement of the height of a chip in order to choose the calibrating parameters for the Hall sensor. In the event that the measurement is outside of the agreed specification, the controller (one of the most expensive components in the entire system) is scrapped. The measurement is made automatically by the testing-measuring station using the CMM (Coordinate Measuring Machine) technology. The result of the measurement is comprised of several factors, such as the deflexion of the board during the measurement, thickness of the protective coating on the chip, as well as the height of the chip itself. An additional disruption to the measurement may be impurities on the surface of the controller’s chip [3].

The problem with measuring the height of the chip on a controller’s board was present ever since the beginning of its production in the company. The number of rejects recorded by the department responsible for analysing the state of the process was significant enough, i.e. the costs to the company resulting from the number of rejects were so high, that the company decided to implement Six Sigma in order to remove or minimise the cause of the defect in the process. The reject ratio due to excessive chip height reached as much as 6%, which is why the company aimed to reduce the number of rejected elements due to the chip’s height (magnet pressing) not conforming with the specification at the measurement stage of the controller’s assembly line. The expected result was a reduction of scrapping costs, improvement of FTQ (First Time Quality) and increasing the line’s efficiency.

The basis for beginning work on the system was determining the current state. It was determined using the measurement method selected (FTQ data). Figure 20.1 shows 13 consecutive production weeks where a reject rate of 2% of the entire production volume was recorded in week 10, 3.45% in week 11 and 6.5% in week 12 respectively; a high value was recorded in week 16-15%, while the highest recorded

reject rate occurred in week 20 and amounted to nearly 17% of the production volume. The green bar shows the goal of 1% to which the reject rate needs to be reduced.

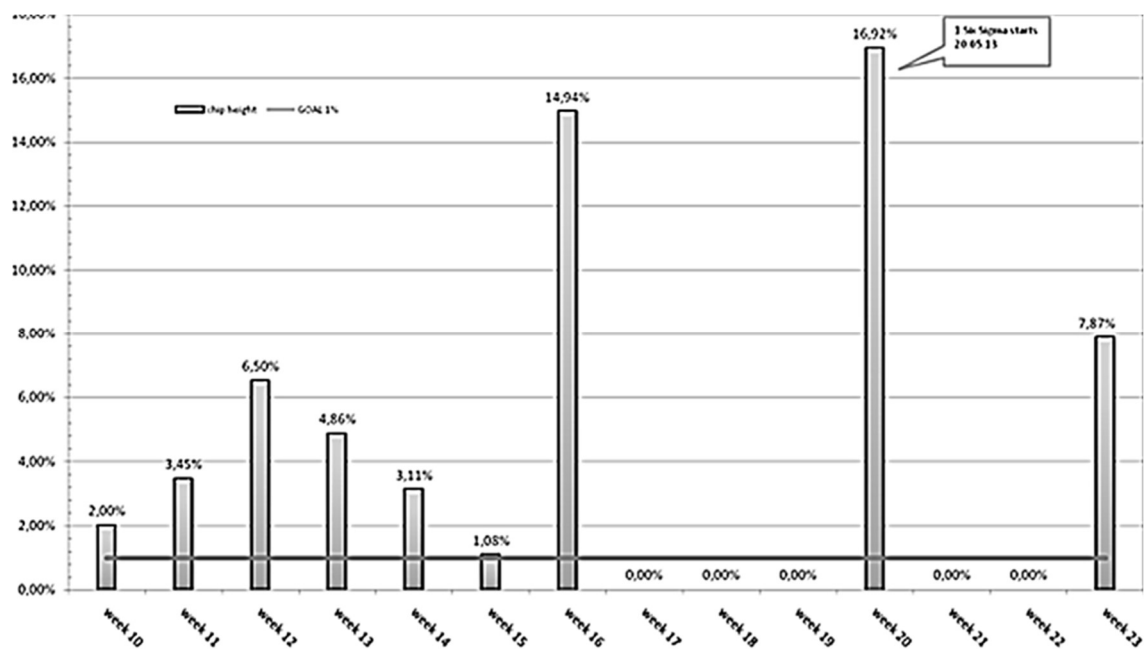


Fig. 20.1. FQT chart of reject rates due to chip height exceeding specification value

Upon defining the basis of the project, an analysis of the current state was conducted. The analysis was carried out according to the assumptions of the Six Sigma method, i.e. the requirements and limitations of the operation performed as well as client's requirements were defined. Following that, a map of the process was prepared, which allowed for the identification of the critical point, which turned out to have been the measurement system. The measurement system used in the process analysed is an automatic station equipped with a CMM. Tests were performed using two sets of ten components each as input, whereby each set was input by a different operator. Next, measurements were made and an analysis of reproducibility was carried out. Figure 20.2 presents the correlation of results. As can be observed in the chart, a very high linear correlation was achieved.

Upon verifying the measurement system, the machine and method were eliminated as a cause of the problem. When studying the measuring system and thoroughly analysing the operating procedure, it was also found that the human factor does not affect the process either. As a result, it was possible to determine the main cause for the increased reject rates in the chip height measurement. Experiments were carried out aimed at determining how the protective coating of the chip affects its height measurement. The experiments' aim was to determine how the chip height measurement is affected by the protective coating put on the chip by the component supplier. In order to conduct the experiment, the coating was removed from the components which were previously measured in order to verify the

measuring system. The components were measured again by the machine. The results are presented in Table 20.1.

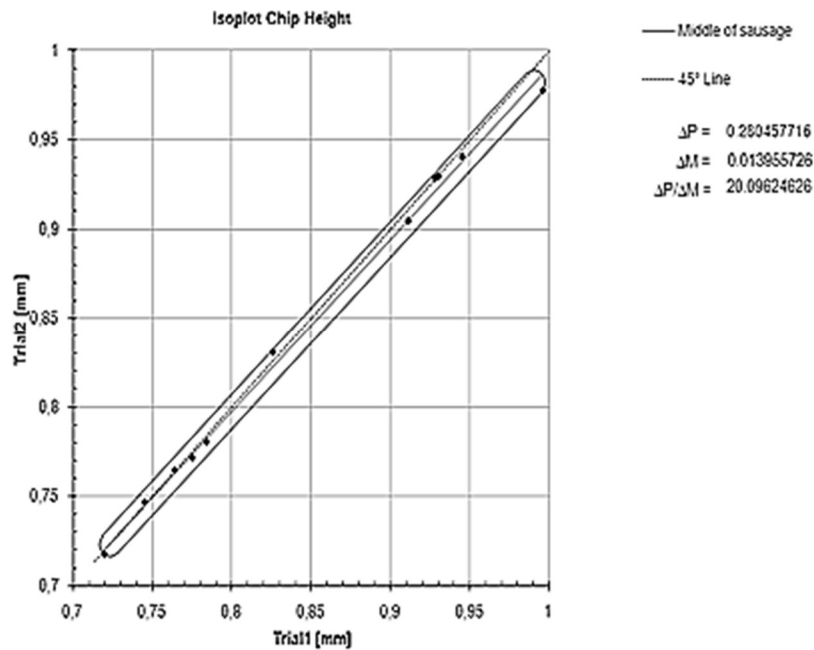


Fig. 20.2 Measurement reproducibility correlation chart

Table 20.1 Results of measurements with the machine

Component	1	2	3	4	5
With protective coating	0.986mm	0.747mm	0.774mm	0.720mm	0.786mm
Without protective coating	1.025mm	0.775mm	0.803mm	0.742mm	0.823mm
Difference	0.039	0.028mm	0.029mm	0.022mm	0.037mm

The results confirmed that the protective coating affected the results of the measurement, but, as is readily visible, removing the coating does not reduce the chip's height. Therefore, it was decided that further analysis should focus on the components being measured. Additional measurements of chip height were performed in a laboratory with reference to the base and PCB measurement. It was observed that PCB bow with reference to the base occurs during the measurement. Height measurement results were very stable and fell within the range of 0.89 mm and 0.05 mm (Table 20.2).

Table 20.2 Laboratory measurement results

Component	1	2	3	4	5
Height measurement with reference to base	0.945mm	0.928mm	0.936mm	0.895mm	0.925mm
PCB bow	0.089mm	-0.114mm	-0.085mm	-0.058mm	-0.076mm
Sum	1.034mm	0.814mm	0.851mm	0.837mm	0.849mm
With protective coating	0.986mm	0.747mm	0.774mm	0.720mm	0.786mm
Without protective coating	1.025mm	0.775mm	0.803mm	0.742mm	0.823mm

Based on the results obtained in the laboratory, it was concluded that the main factor affecting the variability is PCB bow during the measurement. The scatter

diagram showing the correlation between board bow and height measurement of a coated component is presented in Figure 20.3.

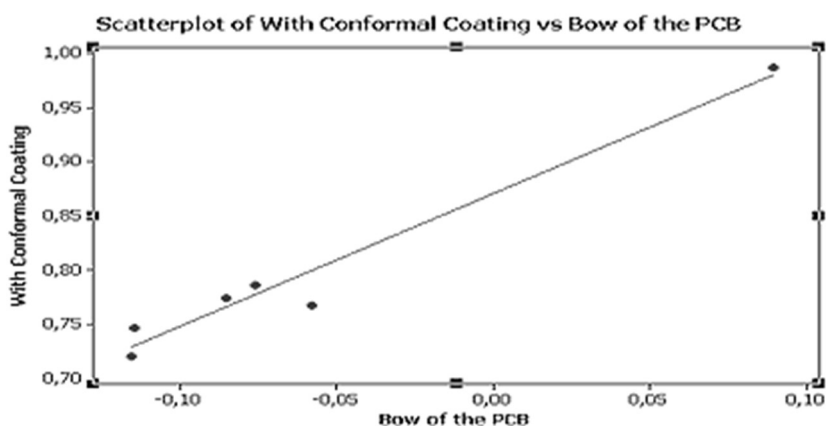


Fig. 20.3. Scatter diagram of the correlation between PCB bow and coated chip height

Knowing the cause of rejection, the company began analysing the possible solutions to the board bow problem. Changing the way the board is mounted during the measurement was considered in order to eliminate its bow, as well as changing the board supplier. It was also decided to analyse the controller's GA drawing, which enabled the conclusion that the board's bow is not taken into account in the drawing. It was therefore decided that the optimal solution which would minimise the costs of rejects without generating costs that would exceed the savings made by eliminating the problem would be accommodating for the board's bow in the GA drawing.

20.4 CONCLUSION

Six Sigma is a method which utilises tools such as: brainstorming, the Fishbone Diagram, FMEA and Pareto analysis, and combines them into one clear and accurate system backed by evidence. The main objective of this method is to eliminate the problem through understanding the underlying cause of variability in the process. In order to properly perform this task, the company must prepare its processes so that as much data are gathered as possible. It is often the case that some data are marginalised until a problem occurs, when it is often too late to find a solution. As a result of the studies conducted that have been presented in the present article, reject rates in the process decreased significantly to a level below 1% of the production volume. This resulted in savings of about three hundred thousand PLN. Additionally, the company gained knowledge on PCB measurement, which can help in preventing similar problems in the future.

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USE OF SIX SIGMA IN THE PRODUCTION PROCESS - CASE STUDY

Abstract: *Issues related to the quality of the final product and the individual components that comprise it are important in every branch of the industry. This is especially true for the automotive branch, where the consequences of quality errors are very severe and costly. The article presents the use of the Six Sigma method for the improvement of the process of height measurement of a controller board chip in a production stream for a premium-class client. The method used, which can be defined mathematically, allowed for minimising the causes for excessive rejection rates of the element in question, which was presented in the article.*

Key words: *six sigma, production process, quality, process improvement*

ZASTOSOWANIE SIXSIGMA W PROCESIE PRODUKCYJNYM – STUDIUM PRZYPADKU

Streszczenie: *Zagadnienia związane z jakością produktu finalnego i poszczególnych komponentów składających się na produkt końcowy są ważne w każdej branży. Szczególnie w branży motoryzacyjnej, gdzie konsekwencje błędów jakościowych są bardzo dotkliwe i kosztowne. Celem artykułu jest zaprezentowanie zastosowania metody Six Sigma do doskonalenia procesu pomiaru wysokości chipa na płytce kontrolera na strumieniu produkcyjnym dla klienta klasy Premium. Zastosowana metoda, którą można zdefiniować w sposób matematyczny, pozwoliła zminimalizować przyczyny zbyt wysokiego odrzutu wybranego elementu, co zostanie zaprezentowane w artykule.*

Słowa kluczowe: *Six Sigma, proces produkcyjny, jakość, doskonalenie procesu*