The Use of Statistical Quality Control Tools to Quality Improving in the Furniture Business

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Abstract

The main aim of the article is to illustrate the use of tools of operative quality management to prevent a decrease in quality during production, supportive and operational processes by the furniture manufacturing. There are more tools for achieving operative quality management targets and the most frequent method is probably measurement and evaluation of the capability of processes through capability indexes. In addition to other histogram and Ishikawa diagram are the next frequently used tools for quality improvement processes.

Keywords: Quality improving; Statistical Process Control; capability indexes; histogram; Ishikawa diagram;

1. Introduction

The current period of economic development along with the market economy can be characterized on a global scale by the high pressure placed on organizations by customers and society itself, both of which have continuously increasing demands and requirements forcing the organization to achieve ever higher levels of efficiency within all business activities by finding new ways and resources to reinforce their position on the market. In order for an organization to satisfy the general and specific needs of its customers, it must continuously increase the level of quality of its own products and services due to the fact that quality is and will remain the decisive factor for stable

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economic growth going forward. Quality management and related activities conducted internally serve this exact purpose and have a combined influence on the overall success of business activities, achieving appropriate returns on investments and improving the economic effects associated with quality in terms of both costs and other returns delivered by the actual quality assurance process. Quality management has become an integral part of organisational management for the majority of organisations and has the primary goal of achieving a desired level of performance while increasing market value and maintaining the entire organisation's market competitiveness. The main aim of the article is to show how we can use the tools of operative quality management to improve quality. They are capability index, histogram, Ishikawa diagram and more.

2. Material and Methods

2.1. The capability index

The main aim of operative quality management is to prevent a decrease in quality during production, supportive and operational processes. There are more tools for achieving operative quality management targets and the most frequent method is probably measurement and evaluation of the capability of processes. For evaluation of the capability of processes, a list of process capability indexes was developed which expresses the capability of a process in various ways. However, it is not only conciseness which is important for their practical use but also intelligibility and simple interpretation. So far, only slight attention has been paid to the interpretation of used capability indexes. Stating the capability index of a process must not be limited to inputting values into appropriate formulae. In order that they have the required explanatory qualities, the method of collecting initial data and fulfilling the limiting conditions are mainly very important. The basic condition is that the evaluated process must be in a statistically managed state since process capability characterises the natural behaviour of the process, induced by the effects of random causes of variability. The second condition which must be fulfilled in case of measurable quality features, when using standard formulae for calculating capability indexes, is normality of a monitored quality feature. Capability indexes are used for evaluating the feasibility of production processes and they compare the prescribed, permitted variability of values given by tolerance borderlines with actual variability of the monitored quality feature.

Capability indexes are used for evaluation of capability and are based on an assumption of normal distribution of values of monitored quality features. An approximate evaluation of whether the measured quality feature values have normal distribution can be ascertained based upon the shape of a constructed histogram. If we obtain a single peak, symmetrical histogram with an approximate bell shape, we can assess that distribution of the values of the monitored quality features is normal. We can also verify the normality of a quality feature value using an exact method, using conformity tests, e.g. \( \chi^2 \), Kolmogorov-Smirnov test or a test based on evaluation of the incline and kurtosis of processed values (Terek, Hrnčiarová, 2004).

Capability index \( c_p \) (fig.1.) is the rate of the potential ability of the process to ensure that a monitored quality feature lies within tolerated quality limits. It can be calculated if both tolerances are specified and its value is a ratio between permitted and actual variability values regardless of where they are placed in the tolerance field. Index \( c_p \) therefore characterises the possibilities of the process given by its variability but does not say anything about how these options are actually used. This can be calculated using the formula:

\[
C_p = \frac{USL - LSL}{6\sigma}
\]

(1)

where: LSL is the lower tolerance limit
USL is the upper tolerance limit
\( \sigma \) is the standard deviation.

Standard deviation can be calculated using the formula:
where \( i \) – the order number of the subgroup

\( j \) – the order number of the measured value in the subgroup

\( n \) – the range of subgroup

\( X_{ij} \) – the measured value in the \( i \)-th subgroup

Unlike the \( c_p \) index, capability index \( c_{pk} \) considers variability as well as the location of the values of the monitored quality feature in the tolerance field and therefore characterises the actual ability of the process to maintain the prescribed tolerances. The \( c_{pk} \) index value can be calculated if specifying double sided as well as single sided tolerances. The following formulae are used for the appropriate calculations:

\[
C_{pk_{USL}} = \frac{USL - \mu}{3\sigma}
\]

(3)

\[
C_{pk_{LSL}} = \frac{\mu - LSL}{3\sigma}
\]

(4)

where \( \mu \) is the median value of the monitored quality feature.
2.2. Histogram

A histogram of frequency distribution represents a graphic form of processing the results of mass discovery or a set of measurements. It is a block diagram which displays the division of absolute or relative frequency of a monitored variable at individual intervals. The base of individual blocks (on the x axis) corresponds to the width of interval, and the height of the blocks (on the y axis) expresses the frequency of variables of the monitored variable at appropriate intervals. In quality management, it mainly refers to the frequency distribution of quality values or values related to production factors influencing the quality of the products.

Information which can be read from a histogram:

- an estimate of the position and diversity of variables of the monitored quality features or the process parameter,
- an estimate of the division shape of the monitored quality features or the process parameter,
- identification of process changes (either comparing histograms and comparing estimates of position and diversity, or by analysing a histogram's shape),
- initial information regarding the feasibility of processes (Tošenovský, Noskievičová, 2000).

2.3. Ishikawa diagram

A diagram of cause and effect (Ishikawa's diagram) which allows disclosure and collection of factors influencing the investigated process or event. It is universal and can be used in almost all areas of human activity. This resolves construction, technological, organisational, economic and social problems, etc. It is called Ishikawa's diagram after its creator, Kaoru Ishikawa but because of its typical shape, it is also known as the "fishbone diagram". Kaoru Ishikawa was a co-author of the Japanese system of company-wide quality management based on informatics. Creating this diagram is based on the fact that every event has an infinite number of causative factors. There are few really important and sharply influencing events (effects). When using Pareto's principle, it is sufficient to inspect just a few more significant factors. The infinite number of causative factors is actually given by the final number of significant factors which depends upon the level of our knowledge. Team work, the inclusion of people from various areas of activity (workers, economists, technicians, research workers, management) are important when seeking significant causative factors. A suitable method for finding causative factors is, for example, brainstorming. After statistical analysis of factors and their verification, they will be added to the cause and effect diagram. The significance of the diagram in the area of quality lies in its function for improving a quality system. The diagram is shaped like a fishbone and the main axis is quality management. The backbone has bones individually placed diagonally and these bones represent axes of main components contributing towards the final quality of the company's products and services. These components - areas - must be harmonised and their interactions provides optimum synergy effect for the company. In terms of logistics, it is a system of seven Ms: - people - MANPOWER, raw materials - MATERIALS, working methods - METHOD, technological equipment - MACHINERY, technical inspection equipment - MEASUREMENTS, other - MISCELLANEOUS, - quality - MANAGEMENT. (Ishikawa, 1985)

3. Results and Discussion

The object of improvement by using statistical tools was weight of adhesive application to components for the manufacture of furniture, where the nominal value of the quality characteristic according to technical conditions and Workflow pressing for oak veneers should be 52 g / m2 within ± 4 g / m2. USL upper tolerance limit = 56 g / m2 and lower tolerance limit LSL = 48 g / m2. The fair value measurement of the quality characteristic are presented in Figures 3-4.
From Fig. 3-4 in measurements D1 - D4, we can see that the interval frequency distribution of the weight of adhesive application with evidence of diversity. Comb shape histograms and capability index values clearly shows that some values do not conform to specifications and selection are beyond the upper and lower tolerance limits, which is not due to natural variation and variability in the process is proof that in the process of occurring systematic causes. Based on the measurements, it was necessary to identify the causes of abnormal behavior of the process using the Ishikawa diagram. The results presented Fig. 5.
To remove and eliminate the root causes of disagreement, we drafted a response plan for the molding process - adhesive coating, which contains a graphical representation of the location of mass values for adhesive application in various zones of control chart and procedures for servicing during setting, measurement, control and transmission of information. Motion response plan for the molding process shown in Fig.6.
Process capability is a technique to find out the measurable property of a process to a specification. Generally, the final solution of the process capability is specified either in the form of calculations or histograms (Kane, 1986). By (ASQ, 1995) the Process capability is the long-term performance level of the process after it has been brought under statistical control. In other words, process capability is the range over which the natural variation of the process occurs as determined by the system of common causes. Process capability is also the ability of the combination of people, machine, methods, material, and measurements to produce a product that will consistently meet the design requirements or customer expectation. (Kane, 1986), (Breyfogle, 1996) and (Ryan, 2011), (Linczényi, Nováková, 2001) and (Nenadál, Plúra, 2008) say that:

- Process capability measurements allow us to summarize process capability in terms of meaningful percentages and metrics.
- To predict the extent to which the process will be able to hold tolerance or customer requirements. Based on the law of probability, you can compute how often the process will meet the specification or the expectation of your customer.
- You may learn that bringing your process under statistical control requires fundamental changes - even designing and implementing a new process that eliminates the sources of variability now at work.
- It helps you choose from among competing processes, the most appropriate one for meeting customers' expectation.
Knowing the capability of your processes, you can specify better the quality performance requirements for new machines, parts and processes.

Montgomery, 2005 say that:

- Cp and Cpk are the most common and timed tested measures of process capability.
- Process capability indices measure the degree to which your process produces output that meets the customer's specification.
- Process capability indices can be used effectively to summarize process capability information in a convenient unitless system.
- Cp and Cpk are quantitative expressions that personify the variability of your process (its natural limits) relative to its specification limits (customer requirements).

4. Conclusion

The paper collected views and opinions of renowned domestic and foreign authors who deal with issues of quality, quality management and the possibility of implementation of methods and tools Statistical quality control. The illustration of using specific tools of quality management in specific conditions of the specific process of furniture production points to the importance of their application and implementation in the identification process capability, in the analysis of the causes of nonconformities and their decomposition of causes, as well as graphic representation of the frequency distribution of measurement results. Their successful implementation is beneficial to improve the quality, competitiveness and performance of businesses.

References