EVALUATION OF THE PROCESSES STABILITY IN METAL INDUSTRY

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Abstract

Stable process can be called a process in which variability is the result of many accidental causes, resulting in minor changes, not a specified number of reasons, resulting in significant changes in the parameter values. In the article the map of process stability, which is a result of process stability (X axis) and product quality (Y axis), was used. This map consists of four areas. The area called “Leave the process without any changes or possibly make small corrections” is the most important and most valuable one. The data for the construction of this map was obtained from the results of BOST survey carried out in the company from the metal industry. At the beginning the structure of the respondents participated in the survey was presented. Analysis of results consists of the number of individual evaluations for both factors, as well as the distribution of evaluation pairs in each area of the map. Statistical analysis of the results was also presented.

Keywords: Process stability, quality, metal products, metal industry

1. INTRODUCTION

A customer, buying a product on the market, expects that it will meet all his requirements. Level of compliance with the requirements decides about the quality of the product.

A process stability is one of the factors determining high quality of the products. By stable process operations, conducted in order to produce a given product, are repeatable, and at the same time products manufactured in such process are repeatable and theirs quality is predictable [1-4].

A process can be called stable if it runs in a consistent and predictable manner. This means that the average process value is constant and the variability is controlled. If the variation is uncontrolled, then either the process average is changing or the process variation is changing or both. There are not only different sources of variation, but there are also different types of variation.

Two important classifications of variation are controlled variation and uncontrolled variation. Controlled variation that is characterized by a stable and consistent pattern of variation over time. This type of variation will be random in nature and will be exhibited by a uniform fluctuation about a constant level.

Uncontrolled variation that is characterized by a pattern of variation that changes over time and hence is unpredictable. This type of variation will typically contain some structure. In the course of process characterization we should endeavour to eliminate all sources of uncontrolled variation [5-6].

The aim of the article is the use of stability map in order to evaluation of the production process of metal products in the rolling mill in one of the Polish steelworks. The analysis conducted in the research company showed the position of this company on the stability map according to its production process and produced products, and thus indicated what actions should be implemented in the company to improve the stability of this process. However, it is not the statistical analysis of the process, but an analysis on the basis of the evaluations given by employees from the research company who have to deal with this process every day.

2. METHODOLOGY

In the research, one of the elements from BOST method was used. The BOST method, that is Toyota's management principles in the questions, is an surveyed method which investigates intangible resources of the company. It is the result of years of research. This survey occurs in two versions: for the employees and for their superiors. With the answers it is possible to evaluate importance in areas such as enterprise mission, quality, standardization, visual control, competitive products and manufacturing process, important areas of improvement, etc. So it is very comprehensive research tool [1]. It should be emphasized that the technical and economic analysis of a company is an integral part of management, including metal industry companies [7-9]. And the BOST method can be part of such analysis.

The map of process stability described in paper [1] was chosen to be used. It has the form of a 2x2 matrix, where the variables are: process stability (X axis) and product quality (Y axis). Both characteristics are evaluated on a scale 1-8, where 1 means low stability or quality and 8 means high stability or quality. This map consists of four areas which can be used as an element of company's plans or strategy. Graphical characteristic of the map of process stability was presented in **Fig. 1**.

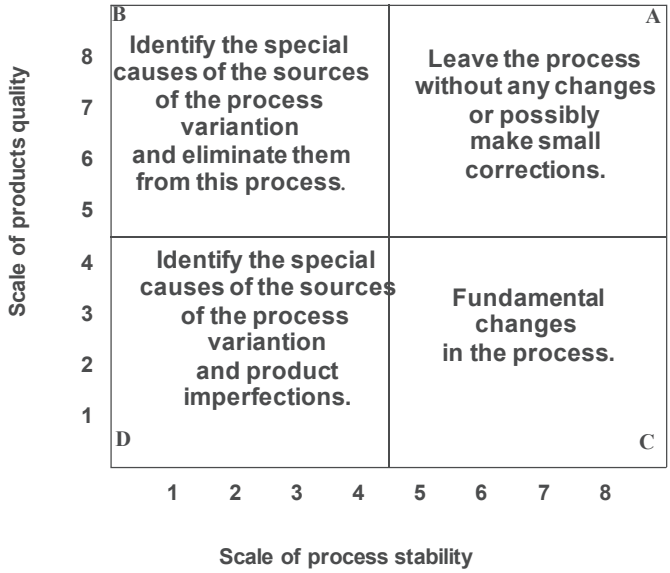

Fig. 1 General characteristics of the map of process stability [1]

The most important area of the map of process stability is the area called "Leave the process without any changes or possibly make small corrections". Such situation takes place when respondents (employees) highly evaluate both the stability of the production process and quality of the products resulting from this process.

3. CHARACTERISTICS OF THE RESEARCH OBJECT

The research steelwork is a modern company with a stable production process, organizational system, friendly for the surrounding environment. The mission of the company is to strengthen the company's position in Poland and abroad as the most efficient producer of long steel products with high quality.

The rolling mill of the research company is a continuous average type of rolling mill. It was launched in 1999. At the beginning its assortment included rounds flat steel bars, round steel bars and reinforced bars.

The research rolling mill is equipped with devices from the company Danieli Morgardshammar. It is one of the most modern rolling mills in Europe, and the most modern in Central and Eastern Europe. In this rolling mill it is possible to implement the stringent requirements of designers connected with engineers or technical

parameters and quality of ribbed bars, for both domestic and foreign market. This rolling mill is still modernized in order to meet the requirements of the customers.

4. CHARACTRISTICS OF RESPNDENTS

The survey was conducted among 37 production workers of the rolling mill in one of the Polish steelworks. In **Table 1** it is shown the general characteristics of the respondents (demographics of the survey). However, in **Table 2** the characteristics of surveyed employees were presented. The research characteristics of the respondents are following: gender (MK), education (WE), age (WI), job seniority (SC) - that is experience, mobility (MR) - that is which place of work, mode of the employment (TR).

Table 1 Features of respondents. Characteristic [own study]

Symbol	Features' marking and their characteristic					
	MK	WE	WI	SC	MR	TR
1	Men	High school	< 30	< 5	1	Regular
2	Women	Professional	31 - 40	6 do 10	2	Transfer
3		Secondary	41 - 50	11 do 15	3	Finance
4		Higher	51 - 55	15 do 20	4	
5			56 - 60	21 do 25	5	
6			61 - 65	26 do 30	6	
7			> 66	31 do 35		
8				> 36		

Table 2 Features of respondents. Percentage characteristic [own study]

Symbol	Features' marking and their rate characteristic					
	MK	WE	WI	SC	MR	TR
1	62.2	32.4	11.2	18.9	29.7	62.2
2	37.8	43.3	30.6	24.4	16.2	16.2
3		5.4	30.6	8.1	21.6	21.6
4		18.9	11.2	18.9	8.1	
5			8.3	16.2	13.7	
6			5.4	8.1	10.7	
7			2.7	2.7		
8	37			2.7		

As it results from **Table 2**, the structure of the respondents participating in the survey was very diverse. However, on its basis, the statistical characteristic of employee who took part in the study can be given. Statistical employee of the research company, who participating in the study, is the man with professional education, aged 31-40 or 41-50 years, with 6-10 years of experience, for who the research company is the first place to work, and who has been employed in the regular mode.

It should be emphasis that the research was conducted in rolling mill in one of the Polish steelworks. Work in such company is hard, intended mainly for the strong young men, regardless of their education. This can explain the structure of respondents in the research company. Women belong to administrative staff.

5. RESULTS

In **Fig. 2** the results of process stability research was presented. The results were given in two forms. From the map of process stability (**Fig. 2a**) exact pairs of evaluations given to both variables can be seen. While from the histogram (**Fig. 2b**) it can be indicted which area of the map of process stability dominates in the research company and identify future activities of the company.

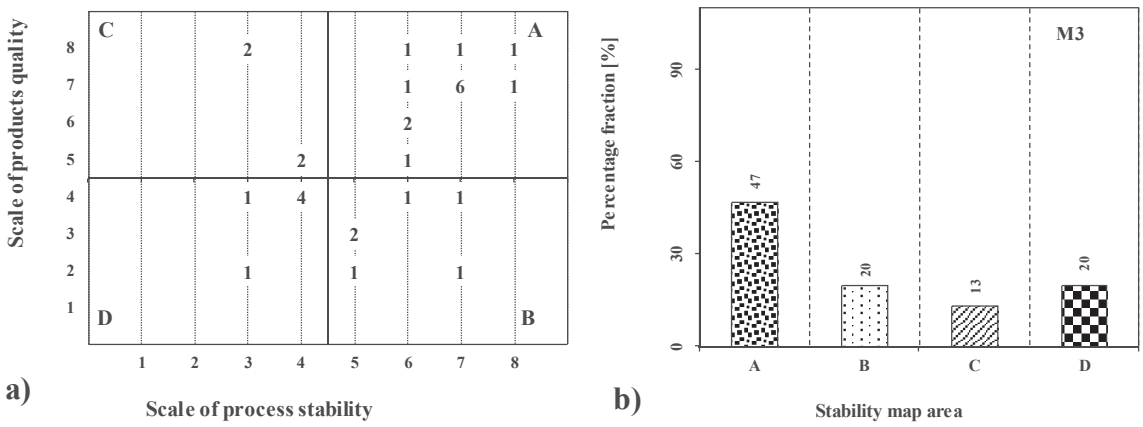

Fig. 2 Process stability: a) evaluations distribution on the map of process stability, b) evaluation structure according to map's area [own study]

Analysing **Fig. 2a** it can be noted that the employees the most often gave two pairs of evaluations: 7;7 (6 times) and 4;4 (4 times). Most of pairs of evaluations of respondents were placed in the middle or up part of the map. **Fig. 2b**, from which it results that most of pairs of the evaluations were placed in area A of this map (47 %), confirmed this fact. It means that for most of the respondents the production process in the research company is stable and at the same time the product quality is adequate. The research company, according to the map of process stability, should leave the process without any changes or possibly make small corrections.

High process stability means that the research company is able to repeat the results obtained during the production process, and at the same time to produce products with constant parameters. This is also reflected in the quality of product, because customers get products with very little diversity in their orders. What is very important especially in the case of the ribbed bars produced by the research rolling mill. Because the order for such product does not include a single piece of the ribbed bars, but large number of the same products.

It is worth noting that none of the employee gave to the process stability evaluation 1 nor 2. The highest evaluation of this factor was recorded twice. While in case of the products quality employees do not gave only evaluation 1, but it is important that evaluation 8 was given to this factor 5 times. Pair of the highest evaluations (8;8) was given during the research only by one respondents, additionally once both pairs 7;8 and 8;7 were given once.

In **Fig. 3** basic statistics of evaluations given to both factors were presented.

From **Fig. 3a** it results that average evaluations of both factors were very similar. The difference between both averages was only 0.03.

Analysing **Figs. 3c and 3d** it can be concluded that the evaluations of the process stability were slightly more diverse (higher value of the standard deviation and coefficient of variation). This fact has also an influence on the greater asymmetry of the distribution of the factor (**Fig. 3e**). However, it should be noted that both the diversity and the asymmetry still are minor.

In **Fig. 4** a box-and-whisker plot presenting evaluations distribution was shown.

A box-and-whisker plot (**Fig. 4a**) provides a wealth of information on the empirical distribution. The location of the box in relation to the numerical axis is the location of the distribution, the vertical line separates them into two sets is a central tendency. On the other hand, the length of the box representing the difference between the first and third quartile, shows the diversity of characteristics for 50 % of the central unit.

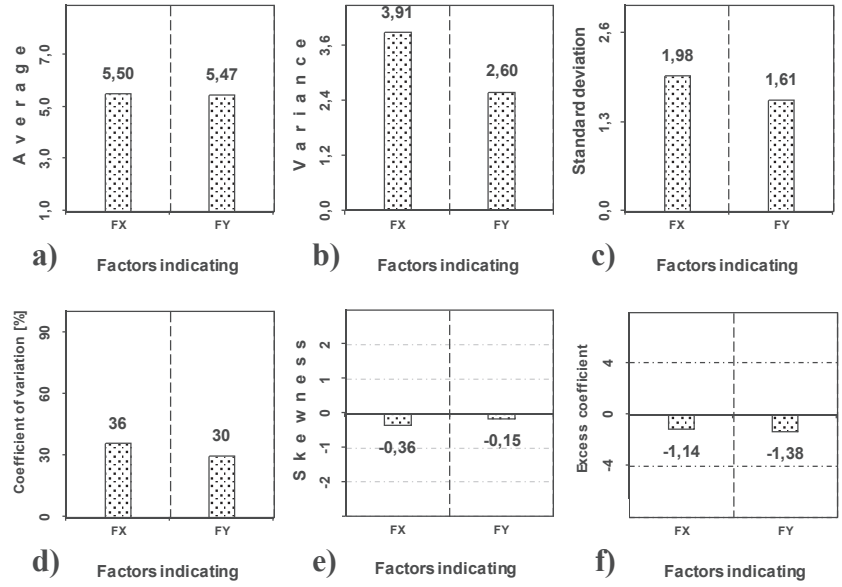

Fig. 3 Process stability. Comparison: a) average, b) standard deviation, c) variance, d) coefficient of variation, e) skewness, f) kurtosis. FX - process stability, FY - products quality [own study]

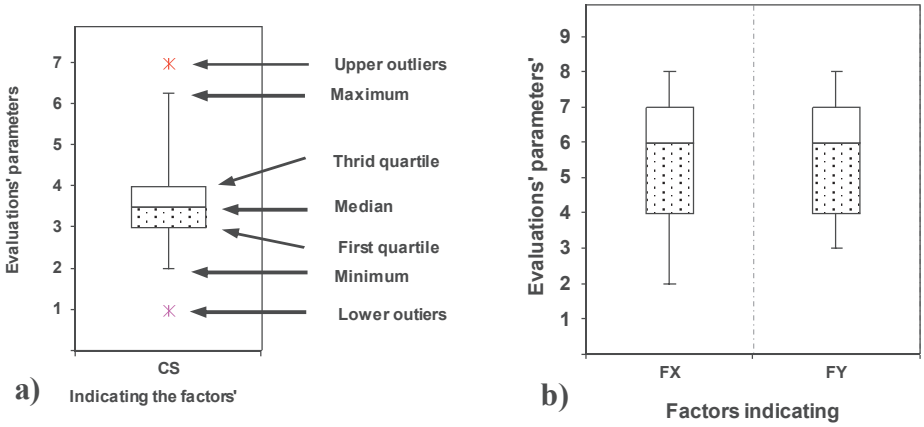

Fig. 4 Process stability. Box-and-whisker plots: a) its characteristics, b) plot for both factors. FX - process stability, FY - products quality [own study]

A vertical line representing the median divides the whole box into two parts, covering 25% of the observations. Depending on the location of the median in the box it indicates skewness in the central part of the distribution.

Complementary part of the plot are "whiskers" located outside of the box. When the whiskers are of equal length, they prove about the symmetry of the distribution. Longer right whisker than the left one shows the positive skewness (asymmetry). Longer left whisker than the right one shows the presence of a negative asymmetry across the distribution.

Correct image of the skewness on the basis of the box-and-whisker plot may be disturbed when some observations "stand out" from the rest, they are denoted with x * (x of "star").

Analysing the box-and-whisker plot (**Fig. 4b**) it is possible to see that in research case there is no observation which "stand out" from the rest. For both variables median is moved up in the range of variation. This is because none of variables got the lowest evaluations, while the highest were given in both cases. In case of process stability distribution is more asymmetric, which is evidenced by whiskers of different lengths.

6. CONCLUSION

Process stability decides about product which is produced during this process, and above all the quality of this product. The process stability and product quality are two factors which can decide about success of the company on the market. The process stability allows the company first of all on repeatability of results, that is, to produce products with constant parameters.

The map of process stability, which is a result of process stability (X axis) and product quality (Y axis), was used to evaluate the process stability and level product quality. The research in form of survey was conducted between employees in the rolling mill in one of the Polish steelworks.

In case of the research company the average evaluations of the process stability and product quality was approximately 5.5. Most pair of evaluations were placed in area A of the map of process stability (47%). It means that for most of the respondents the production process in the research company is stable and at the same time the product quality is adequate. An important element of management in this area of the company operation is continuous observation of the process and the quality of products, which aims to determine if such situation in the near future will not change. However, for now the managers of the company should leave the process without any changes or possibly make small corrections, according to suggestions in the map of process stability.

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