QUALITY ANALYSIS OF THE CHOSEN STEEL PROFILE

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Abstract

Quality is the factor which decides about the efficiency of the company and its image, thereby providing its competitiveness. Quality analysis of the manufactured products provides a lot of information that have an impact on decision-making processes, the performance of the production system, the level of production costs and customer satisfaction. In the paper, the production requirements of the flat-oval steel profile in chosen production plant was presented. Process capability and its adjustment for the production of a chosen batch of oval profiles was described. Analysis of process stability for three different dimensions of profiles was conducted. On the basis of the Pareto chart, groups of problems, which have the biggest influence on the finished product, were determined. Two the most important causes, which generate about 53% of all nonconforming product, were pointed out.

Keywords: Oval steel profile, capability factors, pareto chart

1. INTRODUCTION

Quality (Greek *poiotes*, Latin *qualitas*) - philosophical concept, the first time used by Plato, which recognized the quality of specific things as "a certain degree of perfection". In contrast, Aristotle understood the quality as "the distinction of being". It should be considered in relation to the purpose of being pursued. The essence of the product quality can be understood as a property which characterizes its suitability to efficiently fulfill the function expected from the user. According to European Organization of Quality Control (EOQC) quality: totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs [1].

The main features which determine the quality of the product are following [2-3]:

- efficiency of the product (degree of satisfaction of the needs in the term of use, performance, accuracy and operation economy of the device),
- durability (application period during which the product maintains its properties),
- operational reliability (probability that the product will be able to operate under specified conditions within a specified time).

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. The product quality is very important in case of metallurgical products because they are later used in other production processes to produce other types of products. So their quality has a big influence of the quality of the final products. Therefore, it is very important to conduct quality analysis [2, 4].

In the paper quality assessment of the flat-oval steel profile which was produced by the chosen company during one year was conducted. For this purpose the method determining process capability factors was chosen, the Pareto chart presenting nonconformities arising during production process was included, and a histogram of nonconformities in two-month intervals was shown.

2. CHARACTERISICS OF THE COMPANY

The company "XYZ" has been running production activity for several decades. In the company the Integrated Management System including quality and environmental systems, covering all the requirements according to ISO/TS 16949: 2002 and PN-EN ISO 14001: 2005, was introduced. A product designing was excluded from this System because this stage of work is prepared and presented by a customer. Within the System all processes were identified, a scheme of their connections and matrices were developed. In the technical documentation processes flows, the necessary resources for these processes were specified, ways of their auditing, measurement and monitoring, and full responsibility of the employees for all activities of the production processes were defined. All occurring in the company environmental aspects were defined and later their significance was set. This was the basis for the development of objectives and environmental program for the company, including the technical-organizational and financial possibilities. The research company is a producer of tubes with a high degree of processing: profile, with small diameter, thin-walled, with special strength requirements. The production assortment includes pipes with a wall thickness from 0.5 to 5 mm and a diameter from 4 to 95 mm made of different grades of steel. The next stage of production process is production of flat-oval profiles from these pipes.

3. METALLOGRAPHIC ANALYSIS OF THE FLATT-OVAL STEEL PROFILE

Chosen flat-oval steel profile has following dimensions: major axis 42 mm, minor axis 15 mm, thickness of the wall 2.5 mm [5]. This flat-oval profile was made of steel material produced according to DIN 239101-2 in grade St35 (NBK), its optimal parameters are following: R_e = 280 - 300 MPa, R_m = 420 - 450 MPa, A_5 = 35 - 40%. The research company did not agree for the publication of the figures of production process of finished products and of this product.

The metallographic analysis of the research samples with use of the optical microscope Neophot 2 was conducted. It was found that the microstructure of the research surface was ferritic - pearlitic, on the inner surface of the product there were numerous pits and holes. In addition, a chemical analysis of samples with optical emission spectrometry was also conducted. The result of chemical composition analysis was presented in **Table 1**.

Table 1 Chemical composition (% w.)

No of sample	C	Si	Mn	S	P	Cr	Mo	Ni	Cu	Al
1	0.07	0.21	0.46	0.002	0.012	0.023	0.010	0.042	0.10	0.017
2	0.08	0.21	0.51	0.008	0.014	0.004	0.006	0.013	0.024	0.022

4. QUALITY ANALYSIS OF THE FLAT-OVAL STEEL PROFILE WITH USE OF CHOSEN TOOLS

Calculation of the process capability factors and critical process capability factors of the chosen batch of profiles was made and its results are presented in **Table 2**. The required process capability factor for the individual parameters of the research profile was set at $C_p > 1.3$.

Conducted calculation of the process capability factor for individual parameters of the research profile indicated the precision in production of mentioned profile, moreover, the calculation of the critical process capability factor indicated the correct accuracy of the production technology.

Table 2 Process capability factor C_p of the flat-oval steel profile in chosen year [own study]

Calculated factor	Average value of the measurements	Standard deviation	Process capability factor	Critical process capability factor	
				$C_{p\ krw}$	$C_{p\ krm}$
Major axis 42 mm±0.2	42.0338	0.01116	5.9863	4.9582	7.0032
Minor axis 15 mm±0.2	15.0311	0.01318	5.0736	4.27341	5.8698
Thickness of the wall 2.5 mm±0.18	2.5239	0.01345	4.43827	3.61321	5.2641

In order to determine the quality of the flat-oval steel profile, an analyzes of the stability of the production process of this profile in individual month of the chosen year was made. In **Tables 3, 4 and 5** the results of calculation of the process capability factor for three different measured parameters was presented.

Table 3 Process capability factor C_p of the flat-oval steel profile for the major axis (42 mm) in individual month of chosen year [own study]

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Target C_p	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
C_p	5.21	4.98	5.87	6.53	5.89	6.85	5.96	6.90	5.99	5.97	5.95	5.99

Table 4 Process capability factor C_p of the flat-oval steel profile for the minor axis (15 mm) in individual month of chosen year [own study]

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Target C_p	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
C_p	5.63	5.85	5.02	6.11	5.09	6.12	5.09	6.21	5.28	5.10	5.09	5.23

Table 5 Process capability factor C_p of the flat-oval steel profile for the thickness of the wall (2.5 mm) in individual month of chosen year [own study]

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Target C_p	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1.34
C_p	4.31	4.09	4.42	5.91	4.35	5.89	4.45	4.80	4.71	4.79	4.42	4.39

On the basis of conducted calculations of the process capability factor for three different parameters of the flat-oval steel profile, it was found that there were some nonconformities for the axis 15 mm (in three months) and thickness of the wall 2.5 mm (in two months).

In the next step, material nonconformities of the research flat-oval steel profile occurring during chose year were analyzed. These nonconformities were cause by following material defects: scratches, corrugations, cuts, dents, pits, corrosion holes, poor mechanical properties, scorches, inappropriate diameters, spikes, external contamination internal contamination. During the research year 38.57% of material was treated as nonconforming (**Table 6**).

Table 6 Summary of the nonconformities of the flat-oval steel profile in chosen year [own study]

Denotation of nonconformity	Causes of material nonconformities	Percentage fraction of production, %	Percentage fraction of nonconformities, %	Cumulative percentage, %
N1	poor mechanical properties	3.17	26.36	26.36
N2	cuts	0.8	25.93	52.29
N3	scorches	10	10.05	62.34
N4	scratches	0.47	8.21	70.55
N5	inappropriate diameters	2.76	7.78	78.33
N6	pits	2.2	7.17	85.5
N7	corrosion holes	10.17	5.7	91.2
N8	internal contamination	3.87	2.59	93.79
N9	corrugations	0.53	2.07	95.86
N10	spikes	3	1.55	97.41
N11	external contamination	0.6	1.38	98.79
N12	dents	1	1.21	100
	Total	38.57	100	

In **Figure 1** the Pareto chart for nonconformities of chosen flat-oval steel profile was presented. The quality analysis of the chosen flat-oval steel profile with the use of the Pareto chart let indicate these causes which had the highest impact on quantity of arising material nonconformities [6-7].

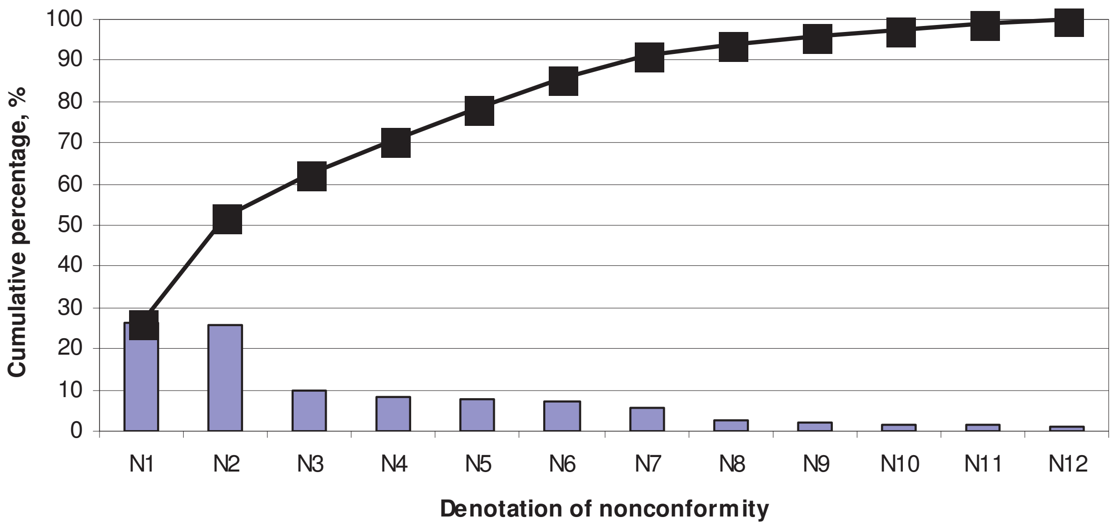

Figure 1 Pareto chart for chosen flat-oval steel profile's material nonconformities [own study]

On the basis of the Pareto chart the main groups of causes of material nonconformities that had the greatest impact on the final product were identified. As a result of this analysis it was indicated that 52.29% of all material nonconformities are caused by 16.62% reason. The most important causes of material nonconformities were: N1 - poor mechanical properties and N2 - cut (respectively 26.36% and 25.93%). So it can be said that 16.62% of causes are responsible for 52.29% of material nonconformities (effects).

The reason of the poor mechanical properties was inadequate heat treatment, while reason of cuts was errors in machine settings and improper finishing treatment. These two causes of nonconformities resulted in disqualification of the product due to the failure of meeting quality requirements [9, 10]. It means that these two causes should be taken into consideration by the company managers in order to improve the quality of the research product [11]. The remaining groups of material nonconformities causes had little importance to the quality of the produced profile.

Calculation of the frequency f (**Figure 2**) presenting percentage fraction of the material nonconformities of the flat-oval steel profile in two-month intervals of the chosen year was made. This analysis helped to indicate the distribution of the material nonconformities in chosen year [8].

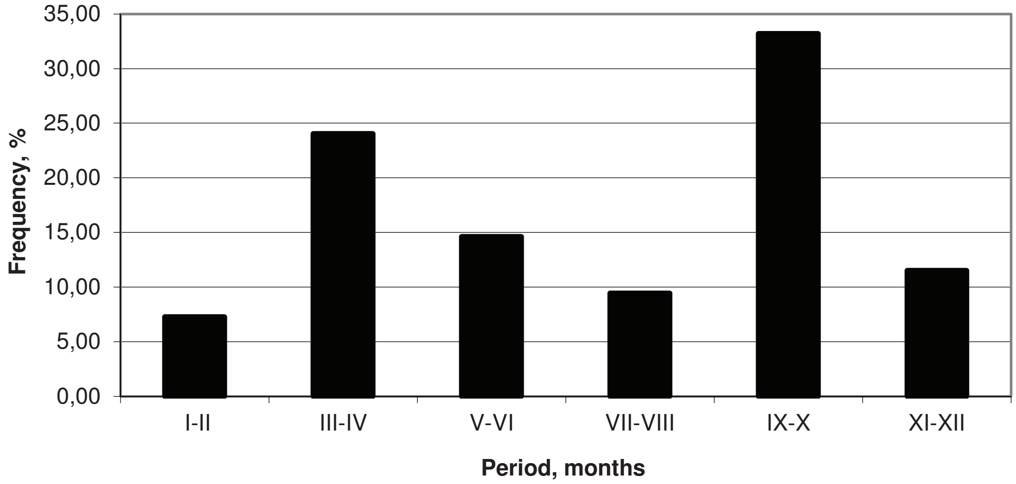

Figure 2 Histogram of nonconformities in two-month intervals of chosen year [own study]

The distribution of material nonconformities was quite diverse. On the basis of **Figure 2** it was concluded that the highest level of material nonconformities was observed in September and October of chosen year, e.g. around 33%, while the smallest level in January and February - around 7%.

5. CONCLUSION

On the basis of the conducted quality analysis of the flat-oval steel profile with the use of chosen tools, the production process of the research product can be assessed. Calculated process capability factors showed that the production process was stable. The use of the Pareto chart let indicate the causes that had the highest impact on the finished product, especially on the material nonconformities occurrence. This let to indicate also areas which should be improved. The use of the histogram let show the distribution of frequency of the material nonconformities occurrence during chosen year. The research conducted in the chosen company should facilitate the correction of the indicated problems and introduction of the corrective actions.

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