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Managing and Improving the Drilling Process of Woodwork Furniture with the Use of SPC Tools

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The article deals with the use of SPC tools to manage and improve the machining process - drilling furniture elements. The content of the article is to use such SPC tools as basic statistical parameters, box plot, histogram, classic and special control charts, and process capability indicators to assess the drilling process and to indicate areas to improve. The article indicates the power of SPC tools in woodwork furniture process control and power of using the Statistica program from TIBCO Software Inc. in this area. SPC tools bring a lot of important and useful information about the analyzed drilling process, its weaknesses, which contributes to the improvement of the process. The conducted study has been shown that the tested drilling process requires improvements, in particular in the area related to the machine and man. The activities that should be implemented to improve the quality of the process were defined, including implementation of the Poka-Yoke system, development of a maintenance inspection schedule, a visual manual for machine setup, employee training with a verification exam, introduction of an employee's suggestion system, modification of the company's motivation system. SPC tools helped to identify the source of process problems, defined a process's stability and capability to meet a customer requirement, and assist with other insights, that were used to define improvement action..

Keywords: Drilling Process, Woodwork Furniture, SPC, Management, Improvement, Statistica Software

1 Introduction

No process is carried out under ideal conditions, not disturbed by any factors. It will never be possible to produce two products with identical parameters - proving this thesis is only a matter of adopting the appropriate accuracy of measurements using a continuous measuring scale [1]. Two types of variation affect each process: random - natural, embedded in the process, the so-called "noise" and special variation - determinate, acting on the process from outside, so-called "signal" [2]. On "noise", we have a limited impact, while on "signals" we have a big impact and we should eliminate them [3]. Variation, caused by "noise" and "signal", separately or together, is inversely proportional to the quality, because if the greater the variation is, the lower the quality [4]. Variation is generated by various process factors such as man, technology, tools, materials [5]; negatively affects the efficiency and effectiveness of manufacturing processes [6]. Improving the production process should constantly focus on monitoring and reducing the variation of product characteristics and production process parameters [7]. Managers' task is to analyze variation using appropriate means to discover the message that variation communicates to us about how to improve the process [8, 9]. Dr Deming, the quality guru, once observed that "virtually uniform product can be achieved only through the careful study of variation in the process and action by management to reduce or eliminate that variation" [1]. To reduce variation, it should be measured and assessed well. For this purpose, SPC tools can be used.

SPC is a philosophy, a strategy, and a set of methods for ongoing improvement of systems, processes, and outcomes [10]. SPC is focused on continuous improvement, mainly by preventive action [11], it means preventing defects by detecting and signalling situations where the process tends to go beyond defined, acceptable limits while identifying the reasons for their occurrence taking into account normal and special deviations [10]. SPC provides early warning of emergent issues, that key personnel on the manufacturing line are alerted and can take appropriate action to resolve the issue and prevent the nascent problem from being a line-stopping problem [12]. Dr Donald J. Wheeler, American SPC guru, in order not to "alienate" others from "Statistical Process Control" because of the presence of the word "statistical" he proposed using the term "Continuous Improvement Method", which also better reflects the purpose of the method [13, 14]. Graphical methods, such as Shewhart's charts (more commonly called "control charts"), run charts, frequency plots, histograms, Pareto analysis, scatter diagrams, box plot diagrams and flow diagrams are the primary tools used in SPC [12]. Statistical process control tools, especially control charts are widely used in manufacturing industries, especially in the Automotive [15, 16, 17], to manage and to improve processes. It was proven that if the SPC is carried out properly and the process is assumed to have the appropriate capability, the risk of producing a non-conforming product - due to the inspected feature - is minimized [18].

2 Research methodology

The aim of the study was to use selected SPC tools, i.e. basic statistics, box plot, histogram, control charts, and process capability indices to analyse and assess the machining process - drilling holes in furniture elements in the selected furniture company to improve the process. Some forest and wood products companies have adopted SPC at several manufacturing facilities, but there is a lack of industry-wide adoption of SPC [19]. The aim of the study was also to indicate the possibilities of SPC tools to manage and control the production process of wood products. The more we know about the process, the better it can be managed. Used SPC tools gave information about weaknesses and problems in the analysed process. The ultimate goal of using SPC tools is to increase customer satisfaction and this goal has been achieved by proposing corrective and improving actions to be implemented in the machining process of wooden elements.

The research object is a medium-sized production, commercial and service company located in the northern part of the Silesian Voivodeship in Poland, which manufactures office, kitchen, and room furniture. The company's main products are computer desks, school desks, corner desks, dressers, shelves, wardrobes, and room furniture.

One of the basic technological operations carried out in the production processes of the majority of manufactured furniture products in the examined company is the operation of drilling holes for furniture-corrugated dowels. Requirements for this operation for a dowel with a diameter of 1.00 cm are shown in Fig. 1.

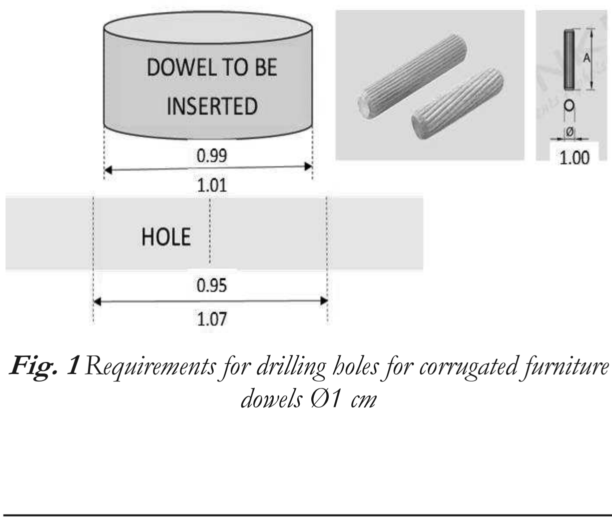

Fig. 1 *Requirements for drilling holes for corrugated furniture dowels Ø1 cm*

When making the assembly process of two wooden parts, the dowel is placed in a pre-drilled hole in one part. On the surface of the dowels, there are small, longitudinal grooves also called gougings. To fix the furniture elements more solidly, joinery glue is added. The adhesive is placed in the hole and then the dowel is pressed. The adhesive is pushed out along the grooves around the dowel making the connection more durable.

The research subject is the drilling process and its result - the diameter of the front hole in furniture elements. The basis for the analysis of the results were measurements of the diameter of holes in manufactured wooden elements with a thickness of 19 to 30 mm (for cabinets, shelves, chests of drawers), which were made for corrugated wooden dowels having a diameter of 10 mm (1 cm), which are mounted in the hole together with adhesive.

In the analysed carpentry shop, a numerically controlled machine tool is used for drilling dowel holes. This machine, in addition to drilling holes, also performs other operations related to the processing of wooden elements, i.e. cutting, milling, and machining contours. The system responsible for drilling - the drilling head is equipped with fourteen vertical and six horizontal spindles.

The wrong diameter of the hole can cause problems when installing wooden dowels in the hole using glue. The too-small diameter of the hole will cause the problem with wooden dowel from being installed or its damage, while too large diameter will cause it to be unstable, too loose in the hole. The consequences associated with the wrong diameter will be larger and worse if the hole diameter is too large - in this case, such a wooden element can no longer be repaired (result: material loss). The consequences will be smaller if the product is too small - the hole can still be repaired, it can be reamed; this is associated with additional work time, using resources and additional quality cost [20]. To effectively manage the drilling process and be able to accurately predict its future behavior, first reliable data from the process is needed. Data for assessing the quality of hole diameters are taken using a "human - measuring device" system, where the measuring device is a 150 mm electronic caliper with an accuracy of 0.01 mm. Measurements are made every two drilled holes. To assess the quality of the drilling process, 84 samples (furniture sets covering various elements) comprising 10 holes were taken. In total, 840 results of hole diameter measurements were available. These data were then subjected to analysis using SPC tools, and conclusions were drawn about the behavior of the studied process over time and about the process capability level. For the statistical analysis aims and graphic results presentation, the STATISTICA 13 program from TIBCO Software Inc. was used [21].

First, statistical analysis of the collected data on hole diameters was performed, which included the calculation and interpretation of basic statistical parameters and their graphic presentation. For the better insight in data and statistical parameters, they were presented graphically with the use of the *box plot* and the *histogram*. *Box plot* was used for graphical representation of relationships between such statistical parameters as median (Me), quartiles (Q1, Q3) and range (R). Box plot provided a lot of information about the empirical distribution: its location, differentiation of the data for 50% of central units, dispersion of data throughout the set [22]. The aim of using histogram was showing how distributed was the range of diameters values, the indication of the most frequently occurred value (the mode), the overall range, and the shape of the distribution (normal or non-normal) [22].

In order to assess the degree of predictability and stability of the process over time X-bar and s control chart was used due to the number of measurements in a single sample greater than 9 (equal to 10) [10]. First, the normality of the data distribution was verified. For this purpose, the Shapiro-Wilk test and normality plot were used. After verifying the normality of the data distribution, the appropriate procedure for a given type of distribution was used to calculate the control limits. After plotting the control charts, roughly it was assessed whether the process was stable in time looking for points outside the control limits. To fully analyze the process behaviour, it was checked whether there was any non-random sequence of points on the X-bar control chart. For this purpose, the runs test were used (7) [10, 21]. To define the runs test, the area above and below the chart, the central line is divided into three "zones" (Fig. 4). By default, Zone A is defined as the area between 2 and 3 times sigma above and below the central line; Zone B is defined as the area between 1 and 2 times sigma, and Zone C is defined as the area between the central line and 1 times sigma [10, 21]. The view of zones A, B and C on the control chart is presented in Fig. 2, while the used run tests (7 in total) are presented in Table 1.

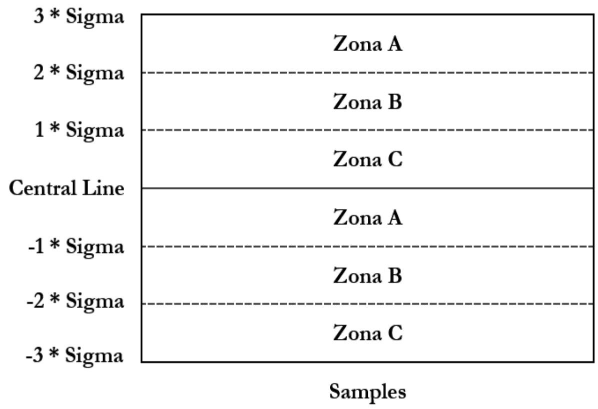

Fig. 2 *The default definition of Zones for Run Tests [21]*

Tab. 1 *Used Run Tests for X-bar Chart [21]*

Run Tests for Control Charts	from sample	to sample
9 points in Zone C or beyond (on one side of central line)		
6 points in a row steadily increasing or decreasing		
14 points in a row alternating up and down		
2 out of 3 points in a row in Zone A or beyond		
4 out of 5 points in a row in Zone B or beyond		
15 points in a row in Zone C (above and below the center line)		
8 points in a row in Zone B, A, or beyond, on either side of the center line (without points in Zone C)		

To assess the process capability to meet customer requirements, process capability indices were used. The indices of Cp, Cpk were calculated based on the corresponding data distribution. The requirement for the tested drilling process is that the diameter of the holes should range from 0.95 to 1.07 cm, with a denomination of 1 cm (LSL = 0.95, NOM = 1, USL = 1.07). The formula for the value of the Cp, Cpk indexes assumes that the nominal value is exactly in the middle of the tolerance field [23], but in this case, this assumption is not met. Due to the asymmetry of tolerance limits for the examined process, Cpm, Cpmk indices were used to assess the process capability, which will be better indices in this case [24, 9]. Cpm index is based on the Taguchi Loss Function and penalized the process manager if the process is out of spec, but also penalized the process manager if the output is off-target [24]. The Cpm index indicates the location of the mean value relative to the target value (TV). The Cpmk index takes into account the shift of the process average relative to the specification limits and its location relative to the target value (TV) [9]. The formulas for calculating the Cpm, Cpmk indices are presented below:

$$C_{pm} = \frac{USL-LSL}{6\sqrt{\sigma^2+(\bar{x}-TV)^2}}\,, \quad (1)$$

$$C_{pmkg} = \frac{USL-\bar{x}}{3\sqrt{\sigma^2+(\bar{x}-TV)^2}}\,, \quad (2)$$

$$C_{pmkd} = \frac{\bar{x}-LSL}{3\sqrt{\sigma^2+(\bar{x}-TV)^2}}\,, \quad (3)$$

$$C_{pmk} = min\{C_{pmkd}; C_{pmkg}\}\,, \quad (4)$$

Where:

USL – Upper Specification Limit,

LSL – Lower Specification Limit,

σ – standard deviation (overall; non-normal distribution),

$\overline{x}$ – mean,

TV – target value (nominal value) [9].

A detailed report on the process capability analysis was presented and also the possibilities of improving the analysed process were indicated based on results.

3 Results

3.1 Assessment of basic statistical parameters

There have been used basic statistical parameters, such as mean $\overline{x}$, median *Me*, mode *Mo*, the minimal value *Min*, the maximum value *Max* the first quartile Q_1, the third quartile Q_3, range R, standard deviation *s*, coefficient of variation V_s, skewness *SK*, kurtosis *KU* to evaluate 840 data concerning the diameter of holes used for dowels in wooden elements produced by the analysed company. The results of the statistical parameters estimation have been presented in Table 2.

Tab. 2 *Statistical parameters estimation concerning hole diameters*

Statistical parameters	$\overline{x}$	*Me*	*Mo*	*No of Mo*	*Min*	*Max*	Q_1	Q_3	R	*S*	V_s	*SK*	*KU*
Summary of hole diameters data set	1.0	1.0	1.0	388	0.95	1.07	0.995	1.010	0.12	0.017	1.71	0.91	1.46

Based on 840 measurements of hole diameters was obtained the arithmetic mean amounts to $\overline{x}$ = 1.0 cm and average diversification ±0.017 cm. The lowest value of assessment of hole diameter equalled 0.95 cm, highest being 1.07 cm, the difference between the highest and lowest assessment in the dataset amounted to R = 0.12 cm. Value 1 cm was the most frequent value in the whole data set (Mo = 1). The calculated median at the level of Me = 1 means that the half of all the hole diameters had value at least equal 1 cm, the same number had value not lower than the indicated one. The relation of $\overline{x}$ = *Me* = *Mo* informs about the symmetry of the analysed data distribution. The first Q_1 and third quartile Q_3 with the value of 0.995 and 1.010 indicate that quarter parts of the analysed holes data set have the diameter no more than 0.995 cm and the same part have the diameter no less than 1.010 cm (the half data of analysed holes was characterized by the diameter between 0.995 and 1.010 cm). Coefficient of variation Vs = 1.71 informs about the low level of difference of holes diameter. Typical area of changeability defined by the equation of $\overline{x} - s < x_{typ} < \overline{x} + s$ for hole diameters amounts to 0.983 cm < x_{typ} < 0.983 cm. The values of about 2/3 of all the hole diameters can be found in this area. Coefficient of skewness is of 0.91 and means low, positive asymmetry of data distribution, the coefficient of kurtosis is of 1.46 indicates a peaked distribution (leptokurtic distribution).

Box plot was elaborated to show the relation between the three statistical parameters such as median, quartile, range (Fig. 3).

The box is generally in the middle of the plot whole which confirms that the whole distribution is symmetrical. The shift of the median close to the first quartile Q1 confirms the right-skewed concerning 50% of the middle data. The lower whisker is shorter than the upper whisker, which indicates right-sided asymmetry of the entire data distribution. The range of values covering 50% of the middle data is between 0.995 cm and 1.01 cm. The non-outlier range is between 0.98 and 1.03. The plot also shows outliers on both sides of the whiskers and extreme values on the upper side of the whisker (1.06 and 1.07).

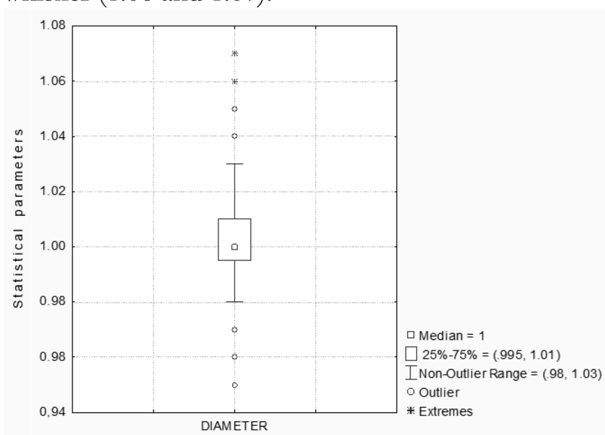

Fig. 3 *Box plot of the median – quartile – range type*

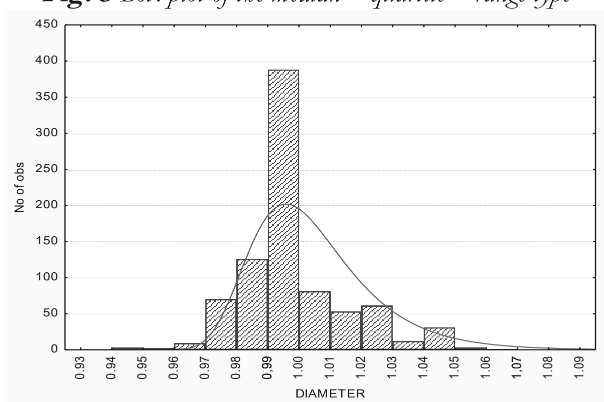

Fig. 4 *Histogram of holes diameters*

Histogram was elaborated to show distribution of data in individual intervals (Fig. 4).

The shape of the histogram indicates the right-skewed distribution of results concerning holes diameters. About 50% of measurements is connected with two values: 1 and 0.99 cm.

How can you summarize the drilling process after analyzing the basic statistical parameters? The process tends to a value of 1 cm, which is the most common value, 388 values out of 840 (46.19%) reach this value, which is generally a positive sign of the process. The variability of the results is small, but the process behaves erratically, which indicates that special causes are at work. The box plot chart indicated more values greater than 1 in the entire data set, also indicated the presence of outliers and extreme values, the occurrence of which undoubtedly must be analyzed and identified as to their cause. Outliers are samples that are exceptionally far from the mainstream of the data. Outliers can have many causes, such as measurement or input error, data corruption, or it can be true outlier observation. These outliers need to require a second look due to their root cause.

3.2 Assessment of the process behavior over time using the X-bar and S control chart

Before assessing the stability and predictability of the drilling process using control charts, the normality of the distribution of results was assessed using the normal probability plot and the Shapiro-Wilk (SW-W) test. The result of the analysis is shown in Fig. 5.

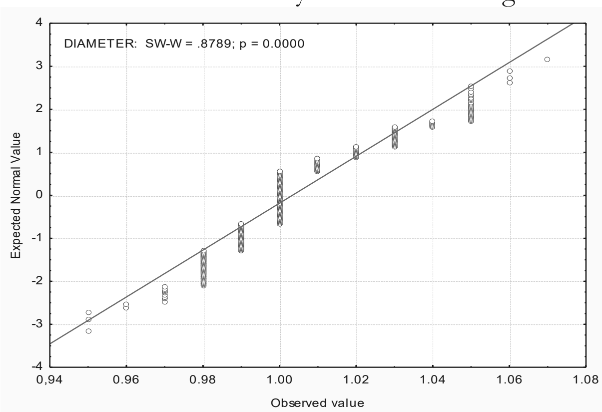

Fig. 5 *Normal Probability Plot of Diameter with Shapiro-Wilk normality test results*

Due to the fact that the calculated p-value is less than the critical value $\alpha = 0.05$, the hypothesis about the normality of the distribution of hole diameters should be rejected. The built normal probability plot also confirms the test result. The distribution of data on the diameter of the holes is a distribution other than normal. This distribution is more right-sided asymmetrical and much slender than the normal distribution curve, which was confirmed also by the calculated skewness and kurtosis indicators (Table 2).

The Shewhart control chart of the mean value and standard deviation (X-bar and S chart) has been elaborated based on samples consisted of 10 elements (Fig. 6). The X-bar chart was built based on control limits calculated for non-normal distribution, based on the so-called Johnson curves [10].

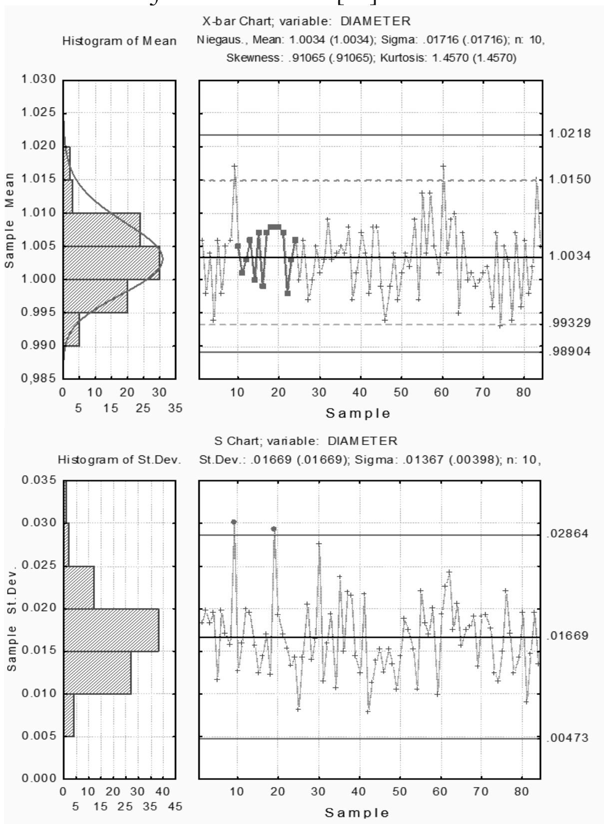

Fig. 6 *X-bar and S control charts for holes diameters: a) histogram of mean and X-bar chart, b) histogram of standard deviations and S chart*

The results of using the run tests for identifying any patterns or trends in the plotted points in the X-bar chart have been presented in Table 3.

Tab. 3 *Results of usage the run tests*

Run tests	from sample	to sample
9 points in Zone C or beyond (on one side of central line)	OK	OK
6 points in a row steadily increasing or decreasing	OK	OK
14 points in a row alternating up and down	OK	OK
2 out of 3 points in a row in Zone A or beyond	OK	OK
4 out of 5 points in a row in Zone B or beyond	OK	OK
15 points in a row in Zone C (above and below the center line)	*10*	*24*
8 points in a row in Zone B, A, or beyond, on either side of the center line (without points in Zone C)	OK	OK

If a process is in statistical control, most of the points will be near the average, some will be closer to the control limits and no points will be beyond the control limits [9]. Due to analysis of the X-bar and S control chart there results that the process was not under statistical control what is claimed by the points placed beyond control limits for the chart S, for samples 9 and 20 and this has also been indicated by conducted specific run test - 15 points in a C area on the X-bar chart. The resulting of 15 points in the C area creates the so-called stratification, where the reason may be measurement data collected from various shifts, from different operators, from different materials. The scheme of the detected pattern of the points set referred to as stratification with potential causes is presented in Fig. 7.

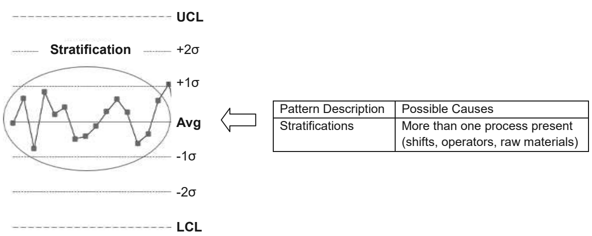

Fig. 7 *Possible causes of stratification pattern*

The EWMA X-bar chart was also used to detect small shifts in the process mean value. EWMA control charts detect shifts of half sigma to two sigmas much faster, they are, however, slower in detecting large shifts in the process mean [25]. The usage of EWMA X-bar chart will allow the company to monitor the degree of wear of the drill and thus maintain the right quality in the production process. The result of using the EWMA X-bar chart is shown in Figure 8.

There does not appear to be an indication of a change in the process mean. However, the process level shifts starting at subgroup 64. It should be noticed a clear trend downwards counting from 64 to 82 subgroup. The process was checked for special-cause variation. The cause was the progressive wear of the tool (drill), which resulted in increasingly smaller holes. Usage of the EWMA X-bar control chart to monitor the results from the drilling process on an ongoing basis will allow preventing the process from quality problems.

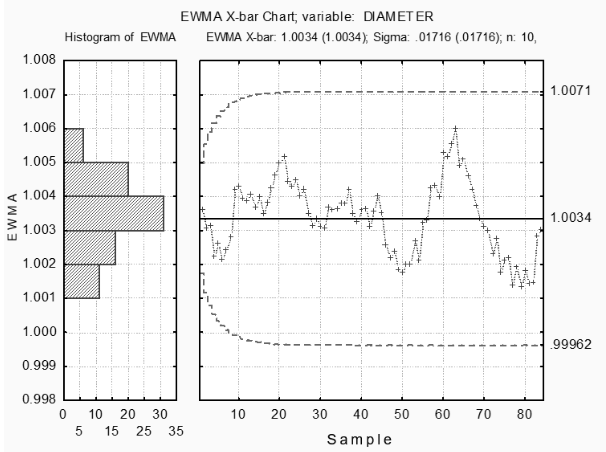

Fig. 8 *EWMA X-bar chart for holes diameters*

3.3 Assessment of the process capability

The result of the drilling process capability study is shown in Fig. 9.

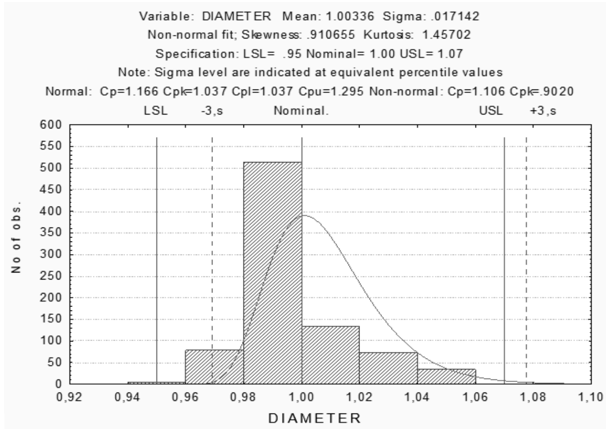

Fig. 9 *Process capability study for holes diameters*

Because the process is statistically unstable as elaborated control charts showed, capability indices based on the total standard deviation (rather than intra-sample deviation, for which the assumption of process stability must be met) were used. Since the tolerance limits for the drilling process were asymmetrical with respect to the nominal, the capability indices Cpm, Cpmk were used. The results of process capability study based on Cpm, Cpmk indices were shown below:

$$C_{pm} = \frac{\mathrm{USL} - \mathrm{LSL}}{6\sqrt{\sigma^2 + (\bar{x} - \mathrm{WD})^2}} = \frac{1.07 - 0.95}{6\sqrt{0.017142^2 + (1.00336 - 1)^2}} = \frac{0.12}{0.3627} = 0.33$$

$$C_{pmk} = C_{pmkd} = \frac{\bar{x} - \mathrm{LSL}}{3\sqrt{\sigma^2 + (\bar{x} - \mathrm{WD})^2}} = \frac{1.00336 - 0.95}{3\sqrt{0.017142^2 + (1.00336 - 1)^2}} = \frac{0,05336}{0.18134} = 0.29$$

Based on the calculated values of the capability indices for other than the normal distribution, it can be stated that the examined process cannot be considered as capable of meeting the requirements, it can cause quality problems in future. The value of the Cpm index is less than 1. The low-quality capability of the examined process is primarily affected by too large results variation, because the process shows only slight non-centring relative to the target value (NOM = 1, mean = 1.003). To improve the process capability managers should be focused on improving (reducing) in this case the variation of the process results. Particularly worrying are the outliers and extreme values on the right side, whose root causes should be identified because it could be special non-standard causes. That such "gross errors" cause false signals on the control chart and could distort the real potential of the process capability. The Cpm, Cpmk indices show how important it is to use them in the analysis of the process under study, in which the target value is not the middle of the specification range, but differs from it. The values of the Cpm, Cpmk indices force the process to be considered as qualitative incapable, so the process needs to be improved.

The results of process capability study using a set of capability indices were summarized in Table 4.

Tab. 4 *Results of Process Capability Study*

Process Capability parameters and indices	Non-normal distribution
LSL (Lower Specification Limit)	0.95
Nominal specification	1.00
USL (Upper Specification Limit)	1.07
CP (potential capacity)	1.11
CR (capacity ratio)	0.90
CPK (demonstrated excellance)	0.90
CPL (CP, lower capabilty index)	1.60
CPU (CP, upper capability index)	0.90
K (non-concerning correction)	0.15
CPM (potential capacity II)	0.33
CPMK (demonstrated excellance II)	0.29

4 Conclusion

The process of drilling holes in furniture elements in the surveyed company, which was assessed using SPC tools, undoubtedly requires improvements. The improvements should include reducing the variation of the process results. The causes of too much variation in the results of the drilling process were identified. The analyzes have shown that the sources of the specified problems lie primarily in two areas: machine and human. The wrong diameter of the holes is the result of wear of the drill and the lack of regular maintenance of the machine (machine), also the incorrect setting of the machine, or the use of the wrong drill by the operator (man). In order to improve the process, a Poka-Yoke system should be introduced that would visually and/or audibly indicate the need to replace the drill after a specific cycle of holes made. An electronic system including a limit switch, controller and induction sensor should be mounted on the drill, which would count the number of drilled holes in furniture elements, after reaching the target critical value, visual and sound information about the need to replace the drill would follow [26]. The employee would not have to wonder whether the drill should already be replaced due to wear or still not. The machine should be regularly maintained and inspected, and worn parts and tools (drills) should be replaced with original or high-quality substitutes. A service schedule should be developed and critical points on the machine requiring inspection of the technical condition in specific cycles (daily, weekly, monthly) by the operator and employee of the maintenance department should be drawn up. Visual instructions as visual conttol tool [27] for setting up the CNC machine (Standard Operating Procedure - SOP) should also be developed and operators should be trained in these activities along with verification of knowledge through a practical exam. It also seems advisable to introduce an "employee suggestion systems" (which is missing in the company), e.g. through an "idea box" and "suggestion form" that would reward employees who propose improvements in the process. This should also increase employee involvement and motivation in improving in the drilling process. Managing and motivating employees and managers system should be flexible and differentiated [28]. It is very important to pay attention to the psychological circumstances of work. Better employees' motivation can be linked to higher efficiency and higher quality production and business results [29, 30]. Analysis of workers motivation system in the company should be done and corrective action should be taken. Implementing a Balanced Scorecard can be a recipe for problems in the company in this area [31].

Based on the analyzes made and conclusions drawn, it should be stated that the use of SPC tools in the field of machining processes in the analysed furniture company can generate a positive effect on the process. In addition to information on the current behavior of the process, SPC tools give the opportunity to predict the future, which is very important in modern company management. The SPC tools, like a fighter plane system, predict events and indicates symptoms of problems before they actually occur. Because if the process has been statistically controlled up to now, is stable in time, what is shown by the control charts, there is a good chance that this will also be the case in the future. If the process is not stable and capable over time, what was shown in the ana-lysed case, there is also a good chance bordering on certainty that this will continue in the future. Hence, the need for managers to take improvement actions in the field of the analysed machining process. Managers in small and medium enter-prises for wood processing and furniture manufacturing should pay the most attention to the product quality [32, 16] and process measurement (MSA) [10]. Peter Drucker, a management expert, once said, "you can't manage something that can't be measured." It is important, however, what and how it is measured (MSA) [10] and also how the data received is analyzed [13]. As was shown in the article SPC tools can be used to manage the production process, predict its future behavior and to improve. By getting data from measurements of hole diameter, subjecting them to appropriate statistical treatment, it was obtained valuable information about the current "nature" of the analysed drilling process to use this knowledge for the purposes of process improvement. Thanks to the use of SPC tools, managers can make faster and more effective decisions regarding the further improvement of the machining process of wooden elements. They gain a competitive advantage because they no longer have to guess, they simply know from data, from measurements, after their statistical analysis, what is wrong with the process, what directs improvement actions. Thanks to this, they can introduce beneficial changes faster in the process, in its individual components (5M) [33, 34]. The benefits of using SPC tools must be understood not only by the employees themselves but also primarily by managers on whom the successful implementation of the SPC system in a company depends. Properly implemented SPC tools positively affect the efficiency and effectiveness of production processes.

The high quality of products is a factor determining the company's survival on the market. The SPC tool allows improving quality all the time by informing about problems with the process stability and capability. The optimized management of quality, with the use of SPC tools, enables in a company an increase in productivity and a reduction of the number of nonconforming workpieces [35]. In the automotive or furniture industry, a methodology such as SPC or Lean that contributes to the reduction of cost and downtime is desirable [36]. The study has shown the need to use SPC tools in machining processes in the furniture industry due to the benefits of increasing knowledge about the process, its weaknesses and strengths because the more managers know about the process, the better they can manage it.

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