METABK 57(4) 349-352 (2018)
UDC – UDK 546.621:669.719:/621-24:531.717:658.562=111

MONITORING THE PROCESS OF ANODISING OF VW70U PISTONS USING THE CONTROL CHART

Received – Primljeno: 2018-02-12
Accepted – Prihvaćeno: 2018-05-20
Preliminary Note – Prethodno priopćenje

The process of anodising of aluminium pistons has been analysed. The analysis has been conducted with the use of a control chart, which is one of the traditional quality management tools. Its purpose is consistent and effective elimination of faults by means of identification of their actual causes and applying appropriate preventive measures. It has been determined that even the most complex control chart, the $\bar{X}$and R chart, can indicate problems within the anodising process and contribute to its improvement.

Key words: aluminium pistons, process of anodising, film thickness, control chart

INTRODUCTION

Dynamic market changes require using more advanced and improved methods of production, employing competent personnel and using management skills. [1] Although these requirements are very high, in practice, most market leaders can skilfully adapt to the demanding business environment. Therefore, quality management or lean manufacturing instruments are gaining in importance. The implementation of these methods and tools allows to lower the costs of production and improve the quality of products. Various methods of quality improvement are available. [2-4] One of them is the use of a statistical process control (SPC) tool, such as the control chart. The grounds of the SPC method were developed in the 20th century by Walter A. Shewhart. [5]

They are still helpful in controlling the changes and stability of the process. The major purpose of the SPC method is analysing the process in terms of its correctness and efficiency within the specified limits. The SPC method is used in supervising processes and delivery control, as well as in monitoring of measurement equipment. This tool ensures measurable effects, contributing to the reduction of various costs, from those related with the manufacturing process, and ending with the costs of complaints. Control charts enable to indicate specific areas for improvement and suggest corrective actions that would allow to avoid similar faults in future. Quality management procedure based on the use of the control chart has been conducted with a piston manufacturer from the Subcarpathian Region in Poland. The described tool has been used in stabilising the production process of a new piston, undergoing the anodising procedure. [6-8] This particular operation, due to difficult control, has been analysed with the use of a control chart.

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ANALYSIS

Purpose of analysis

The aim of the analysis was the assessment of stability of the anodising process performed on pistons to be introduced to production, with the use of the X-R control chart. The preliminary step was the analysis of potential causes and effects of failures (FMEA), which indicated that one of the most significant potential sources of problems could be the thickness of the anodic film. [9, 10] Stability of production process of other pistons have been analysed before. [11, 12] However, those analyses concerned structural dimensions. [13, 14] Their purpose was to determine if, and to what extent, the difficult piston anodising process was out of adjustment.

Anodising

Anodising process is performed in the electrolyte with the following composition: Sulphuric acid 260-300 g/litre, Ecolyte HA 99,4 - 12÷18 g/l (oxalic acid 6,5-8,5 g/litre, boric acid 2,5-3,5 g/l), max. aluminium (Al) content 6 g/l, temperature -5 - + 9 ° C.

Optimum electrolyte composition parameters and optimum process parameters are as follows:

I Electrolyte composition:
- sulphuric acid: 290 g/l,
- oxalic acid: 15 g/l,
- AlOx: 1:10 %;

II Process parameters:
- Current strength: 4 A

- Time: 180 s,
- Temperature: 10 ^{0}C.

The analyses have been conducted at the manufacturing plant in Poland with the following types of pistons:

- VW 70A/; SN2 material,
- VW 70U/; S2F material (forged pistons).

Methodology of analysis

The company uses 10 anodising lines, including 2 automatic and 8 manual. The anodising process is performed with 22 types of pistons. The company, in cooperation with the Institute of Precision Mechanics in Warsaw, is performing a research project aimed at testing new technologies of anodising without the use of Cr6+. The goal is to obtain anodic film with lower coarseness. For that reason, the company decided to perform a thorough monitoring of the process. The required parameters of anodic films of pistons manufactured at the described plant are as follows:

- thickness: 10-20 micrometres,
- hardness: > 270 HV,
- coarseness: Ra< 2,5um.

This study focuses on the analysis of results of anodic film thickness tests (it should be from 10 to 20 micrometres, as it has been specified above).

The quantity of test pieces for analysis was determined mainly on the basis of the costs of control, the character of the process, and also technical and organisational capabilities. Considering the method of collection and the cost of that procedure, the average quantity of 1 test piece per shift has been determined. It would allow to get reliable data and results for further analyses and to avoid high costs of control. It has also been decided that test piece measurements would be performed in 4 repetitions.

Each measurement was performed by the materials laboratory technicians with the use of ZEISS microscope. 200 x magnification and accuracy scale of 0,01 um were used. The test pieces were cut out using the Brilliant 250 cutter and then mounted in order to ensure appropriate position and quality of specimen.

RESULTS AND DISCUSSION

Calculated using statistical formulas and statistical analysis IT tools, including Mnitab software.

The test concerned anodising capability of the VW70U piston. Results and calculations are presented in Table 1 and Figures 1, 2.

The spreadsheet presented in Figure 2 has been obtained. This model has been generated with Microsoft Excel software, due to its easy operation and costs savings.

The introduction of the $\overline{X}$ and R control chart will allow to continue process regulation monitoring. The application of this statistical tool allows to take almost immediate actions if any hazardous deviations occur. It is comfortable for the manufacturer and facilitates constant improvement of products. The introduction of control charts in the described processes may be considered a sort of experiment that allowed to extend the knowledge concerning, among others, the factors that may have effect on the quality of the process.

One of the examples was the occurrence of deviations in the control chart of the VW70U pistons anodis-

Table 1 **Measurements performed with VW70U pistons**

		Test piece No.			
		1.	2.	3.	4.
Part No.	1	13,53	12,99	13,13	13,99
	2	15,23	15,44	16,03	15,55
	3	16,04	16,09	15,26	15,56
	4	15,89	15,23	15,96	15,78
	5	13,03	13,63	14,22	14,63
	6	15,86	15,23	16,03	16,02
	7	17,63	15,63	15,96	15,74
	8	16,08	16,23	16,22	15,56
	9	16,67	15,88	14,79	14,30
	10	14,77	14,13	16,32	13,21
	11	13,96	14,64	15,23	13,03
	12	17,01	16,25	14,99	17,23
	13	16,55	16,33	14,23	13,66
	14	14,53	14,36	15,36	15,12
	15	16,18	16,75	15,26	15,45
	16	16,89	15,52	15,26	15,45
	17	16,31	14,36	15,85	15,63
	18	15,86	15,03	16,23	14,01
	19	16,33	16,33	16,23	13,33
	20	13,12	14,95	14,56	16,25

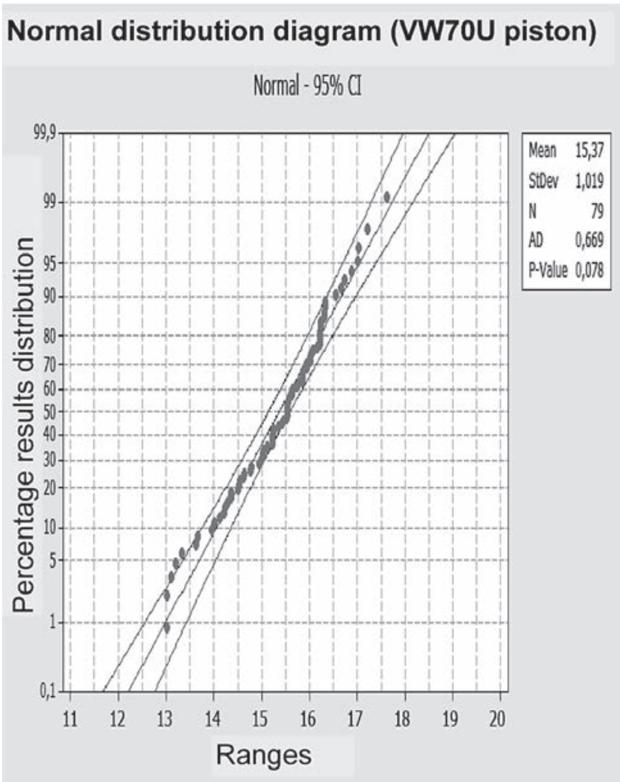


Figure 1 Normal distribution of anodic film thickness results for the VW70U piston

ing process. Regularly entered results indicated changes that could be verified, diagnosed and corrected. The company has decided that control charts would be introduced and used as tools for recording results, monitoring and improving the quality of company operations.

It has also been agreed that control cards would be introduced in future for analysing other processes. Furthermore, the decision has been made that in the nearest time the control chart form would be supplemented with additional data, while in future the company would endeavour to get access to software dedicated mainly for statistical analyses. To sum up the conducted analyses, the system presented herein requires many improvements, and above all, experience of the users.

Skills in interpreting results and making appropriate decisions are also important. The use of the control charts has confirmed that anodising processes of selected piston types were properly adjusted, and good in terms of quality.

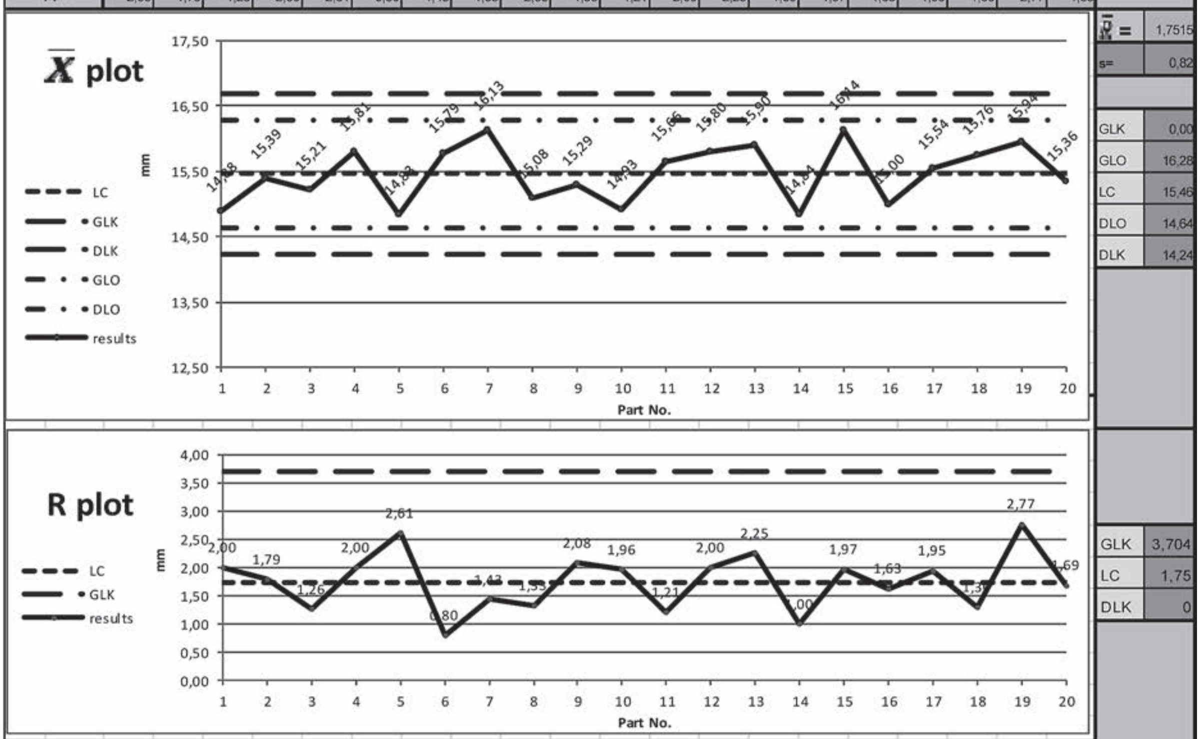
CONCLUSION

The described company is a manufacturer of pistons supplied to clients all over the world and used mainly in combustion engines. Buyers of pistons supplied by the company-based plant more often trust the quality of the delivered parts and resign from special verification.

$\bar{X}$ and R Control Chart	Process parameters:		Prepared by:
VW70U PISTONS ANODISING	Current strength:	4:00 AM	Date:
Chart No:	Time:	180 / s	Tolerance : 15 ±5 / mm
Measurement: film thickness / mm	Temperature:	10 / °C	

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Date:	20.11	20.11	21.11	21.11	24.11	24.11	25.11	25.11	26.11	26.11	27.11	27.11	28.11	28.11	1.12	1.12	2.12	2.12	3.12	3.12
Time:	11.00	16.50	10.45	16.45	10.50	16.00	11.00	17.20	10.00	16.15	9.30	16.00	10.00	15.30	10.00	16.00	9.30	16.00	10.00	15.30
Test Piece No. 1.	13,53	14,23	16,04	16,86	15.79	15,86	16,99	14,23	16,44	15,25	15,02	16,99	16,44	14,53	16,2	16,89	16,31	15,69	16,99	15,66
2.	15,53	15,44	15,03	16,25	13,63	15,23	15,56	15,56	15,69	14,43	16,02	15,57	16,88	14,36	16,33	15,52	14,36	16,33	16,33	14,95
3.	15,23	16,02	14,99	15,26	16,24	16,03	15,94	14,98	14,65	15,99	16,23	14,99	15,63	15,36	15,02	15,26	15,85	15,99	16,22	14,56
4.	15,23	15,86	14,78	14,86	14,63	16,02	16,02	15,56	14,36	14,03	15,36	15,63	14,63	15,12	16,99	15,45	15,63	15,03	14,22	16,25
$\bar{x}$=	14,88	15,39	15,21	15,81	14,83	15,79	16,13	15,08	15,29	14,93	15,66	15,80	15,90	14,84	16,14	15,00	15,54	15,76	15,94	15,36
min=	13,53	14,23	14,78	14,86	13,63	15,23	15,56	14,23	14,36	14,03	15,02	14,99	14,63	14,36	15,02	15,26	14,36	15,03	14,22	14,56
max=	15,53	16,02	16,04	16,86	16,24	16,03	16,99	15,56	16,44	15,99	16,23	16,99	16,88	15,36	16,99	16,89	16,31	16,33	16,99	16,25
R=	2,00	1,79	1,26	2,00	2,61	0,80	1,43	1,33	2,08	1,96	1,21	2,00	2,25	1,00	1,97	1,63	1,95	1,30	2,77	1,69

$\bar{\bar{X}}$ =	15,46
$\bar{R}$ =	1,7515
s=	0,82



$\bar{x}$ - average values from tests	R –test range
min – minimum value of a test	s – standard deviation
max – maximum value of a test	R – average range

Figure 2 The $\bar{X}$ and R control chart

Quality monitoring, performed mainly with the use of the Control Chart, has indicated that this particular change in the anodising process resulted in better aesthetics of pistons and improved functional properties, mainly hardness, thickness and coarseness.

The control chart, integrated with the Control Plan, has proved to be a quite effective quality control tool in piston manufacturing, including its integral part, that is the anodising process.

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Note: The English Language translation was done by D. Piłat, Rzeszów, Poland