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Use of SPC (Statistical process control) for quality control and management of an automatic production line

Valentin Tsenev
College of Energy and Electronics
TU Sofia
Botevgrad, Bulgaria
vtsenev@tu-sofia.bg

***Abstract*—The SPC (Statistical process control) method was used to assess the quality in the production of connectors and the model remained permanently active for process stability control. Based on the collected data, SPC analysis was performed using the software product QSTATLAB and a measurable score was obtained by PPK and CPK (measures of stability and suitability of the process). Based on the obtained results, actions have been taken to improve the quality of the manufactured product. A conclusion was made on the basis of the obtained results with conclusions regarding the preservation of the stability and suitability of the process.**

***Keywords*— quality, control, measurement, stability and suitability**

I. Introduction

In modern production processes, reliable methods for process control and management are used [1]. A modern method for process control and management is SPC [2], which through statistics and analysis of the results obtained during the production process assesses its progress. Many software products [3, 4] are used for the application of SPC, in which there is a built-in module for SPC control. The evaluation parameters are PPK and CPK [5], which are measures of stability and suitability of the process. Based on statistics and analysis, PPK and CPK are determined, which are an assessment of the stability and applicability of the process.

The procedure for conducting the SPC includes the following steps:

1) Recording of the control parameters of the process in control charts;

2) Processing of records in control charts and generation of histograms;

3) Processing of the obtained results and calculation of PPK and CPK;

4) Comparison of the obtained PPK and CPK with the control limits;

5) Impact for improvement on the process at parameters outside the limits based on the analysis of the obtained histograms.

The PPK and CPK parameters in this case must be greater than 1.67 [6], as the connectors produced are for the automotive industry.

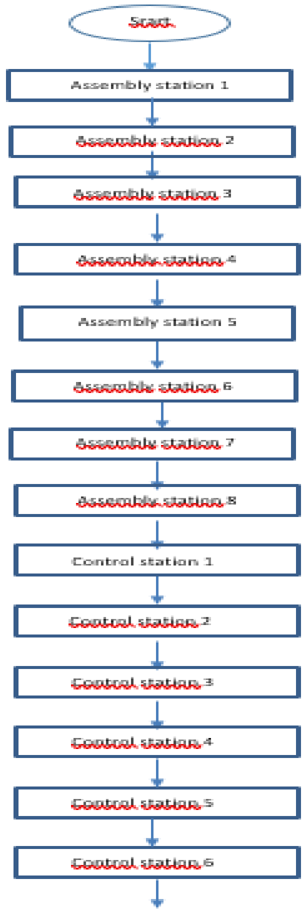
The deviations are caused by various problems - the operation of the machine, the condition of the tools and patterns, the quality of the materials, the influence of the environment, the setting of the control stations, the training of the operators and others.

II. Experiments

The production process takes place in several steps:

- Injection molded plastic body;
- Assembly of metal terminals in the plastic body;
- Automatic 100% product control for functionality-critical features.

In fig. 1. the algorithm for operation of the assembling and control part of the production line is shown:



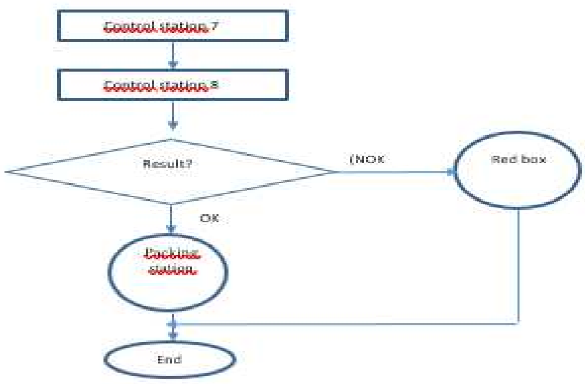


Fig.1. Algorithm for the operation of an automatic assembly production line

In fig. 2. the control stations of the automatic production line are shown.

Fig. 2. Control stations on an automatic production line

The controlled parameters are:

- control for missing pin, short or long pin from interface side;
- critical dimensions;
- distorted terminal on the PCB side;
- distorted terminal output side;
- control for delays from inclusions and pollutants.

The control stations work on the principle of using patterns and electrical measurements for the presence or absence of contact and circuit. A station for a pass for a suitable product is provided. Nonconforming products are automatically separated in a special red box. Suitable products come for packing at the packing station shown on fig.3.

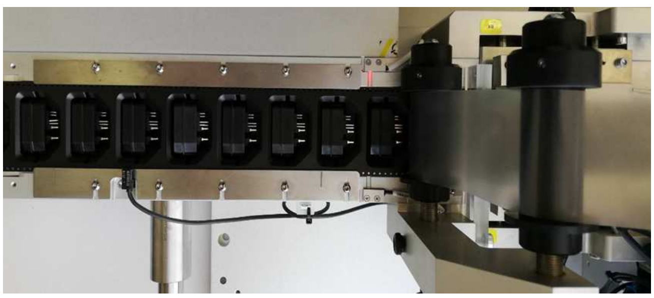


Fig. 3. Packing station

III. Results

a) The study was performed with 30 connectors taken every 1 hour from the total set of manufactured parts. For this purpose, these samples are measured at critical dimensions with a precision measuring instrument digital microscope Mitutoyo - model CNC Quick Scope QS-250. The overall measurement results are shown in Table 1. The deviations are estimated.

TABLE I.

202-646824-00-299 Drawing No: 64 68 245/rev.01-17.09.2019				
(1.02) ⌖ Φ0.6 I J				
Cavity No- Sample No	**Pin 1 Interface 2**	**Pin 3 Interface 2**	**Pin 1 Interface 1**	**Pin 7 Interface 1**
1	0.171	0.098	**0.205**	0.235
2	0.132	0.105	0.352	0.245
3	0.132	0.089	0.312	0.211
4	0.100	0.095	0.385	0.019
5	0.115	0.125	0.357	0.160
6	0.161	0.099	0.325	0.205
7	0.152	0.086	0.326	0.203
8	0.130	0.102	0.324	0.254
9	0.128	0.123	0.329	0.221
10	0.108	0.102	0.365	0.215
11	0.126	0.087	0.345	0.214
12	0.104	0.112	0.210	0.189
13	0.128	0.108	0.426	0.196
14	0.156	0.086	0.350	0.207
15	0.211	0.071	0.308	0.178
16	0.121	0.108	0.289	0.214
17	0.168	0.135	0.306	0.201
18	0.128	0.085	0.289	0.210
19	0.139	0.110	0.378	0.231
20	0.127	0.096	0.341	0.199
21	0.114	0.105	0.321	0.203
22	0.132	0.075	0.289	0.201
23	0.114	0.086	0.256	0.198
24	0.139	0.047	0.341	0.214
25	0.187	0.089	0.356	0.189
26	0.145	0.121	0.364	0.198
27	0.126	0.087	0.346	0.203
28	0.123	0.094	0.325	0.214
29	0.110	0.096	0.354	0.215
30	0.108	0.110	0.311	0.203

The measurement results were processed using the software product QSTATLAB, which has the built-in SPC method and are shown on fig. 4.

Файл Редакция Диаграми и методи QstatLab

Cavity 1_Process Capability Study_Magna_g8680x.qsl

Ред 1; Колона 1 --> 1

	A	B	C	D	E
	Nomer	1.02 (0+0.6)-pin1_int2	1.02 (0+0.6)-pin3_int2	1.02 (0+0.6)-pin1_int1	1.02 (0+0.6)-pin7_int1
1	1	0,171	0,098	0,205	0,235
2	2	0,132	0,105	0,352	0,245
3	3	0,132	0,089	0,312	0,211
4	4	0,100	0,095	0,385	0,019
5	5	0,115	0,125	0,357	0,160
6	6	0,161	0,099	0,325	0,205
7	7	0,152	0,086	0,326	0,203
8	8	0,130	0,102	0,324	0,254
9	9	0,128	0,123	0,329	0,221
10	10	0,108	0,102	0,365	0,215
11	11	0,126	0,087	0,345	0,214
12	12	0,104	0,112	0,210	0,189
13	13	0,128	0,108	0,426	0,196
14	14	0,156	0,086	0,350	0,207
15	15	0,211	0,071	0,308	0,178
16	16	0,121	0,108	0,289	0,214
17	17	0,168	0,135	0,306	0,201
18	18	0,128	0,085	0,289	0,210
19	19	0,139	0,110	0,378	0,231
20	20	0,127	0,096	0,341	0,199
21	21	0,114	0,105	0,321	0,203
22	22	0,132	0,075	0,289	0,201
23	23	0,114	0,086	0,256	0,198
24	24	0,139	0,047	0,341	0,214
25	25	0,187	0,089	0,356	0,189
26	26	0,145	0,121	0,364	0,198
27	27	0,126	0,087	0,346	0,203
28	28	0,123	0,074	0,325	0,214
29	29	0,110	0,096	0,354	0,215
30	30	0,108	0,110	0,311	0,203

Fig .4. Initial measurement data

The following results were obtained from the data analysis:

A. SIZE 1.02-POSITION OF PIN 1 INTERFACE 1.

In fig. 5. the results for pin1 interface 1 are shown.

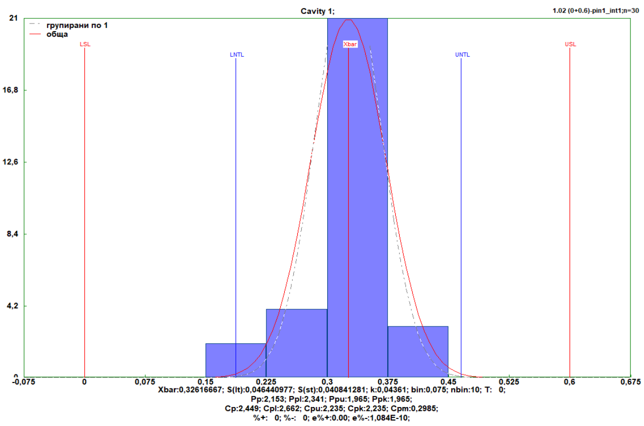


Fig. 5. Histogram for the distribution of deviation for size pin 1 interface 1

The achieved results are CPK = 2.235 and PPK = 1.965, which meets the requirements [6] and significantly exceeds them. It is not necessary to check, adjust and improve station 6. The pattern used is not worn and does not need to be checked, replaced or improved in its part, which controls the described size.

B. SIZE 1.02-POSITION OF PIN1 INTERFACE 2.

In Fig. 6. the results for pin 1 interface 2 are shown.

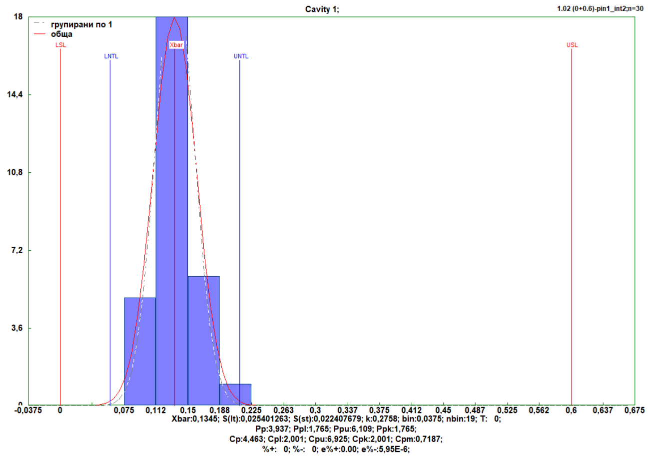


Fig. 6. Histogram for deviation of distribution for size pin 1 interface 2

The achieved results are CPK = 2.001 and PPK = 1.765 and are acceptable [6].

C. SIZE 1.02-POSITION OF PIN 3 INTERFACE 2.

In fig. 7. the results for pin3 interface 2 are shown.

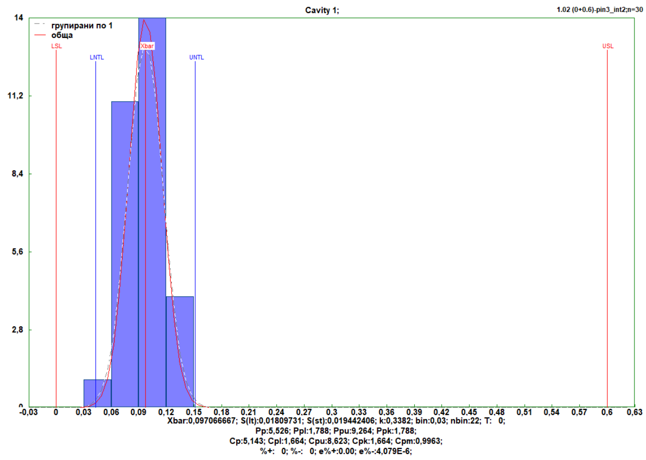


Fig .7. Histogram for the distribution of the deviation for size pin 3 interface 2

The achieved results are CPK = 1.664 and PPK = 1.788, which are marginal and in this part the pattern needs to be repaired or replaced.

D. SIZE 1.02-POSITION OF PIN3 INTERFACE 2.

In fig. 8. the results for pin 7 interface 1 are shown.

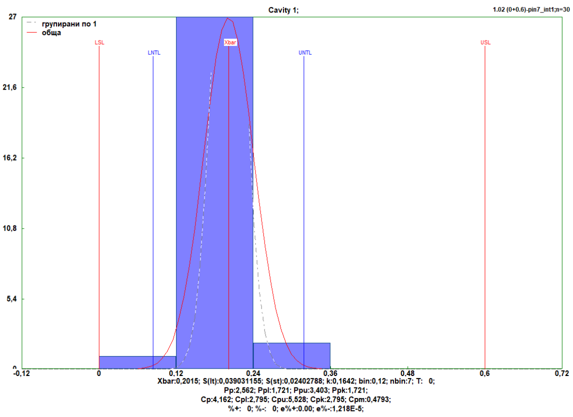


Fig. 8. Histogram for deviation of distribution for size pin 7 interface 1

The results achieved are CPK = 2.795 and PPK = 1.721 and are acceptable.

Improvements were made using the analysis. One of these improvements is related to a change in the design of one of the pattern of station 6, which, with prolonged use, created a defect of the "plastic shavings" type. It was concluded that due to the presence of eight sockets in the tool for the production of the plastic part, there are differences in size between them. All the details are in the customer's requirements, but there is still a conflict between the pattern and the tested part. It was recommended to place a compensating device of the pattern, which would absorb the difference between the sockets and prevent the occurrence of this defect. The compensating device is a group of mechanical components between which there is a "soft" connection. This soft connection compensates for incorrectly positioned parts relative to each other with a difference in the dimensions of the opposite part. In Fig. 9. the principle of operation of a compensating device is shown.

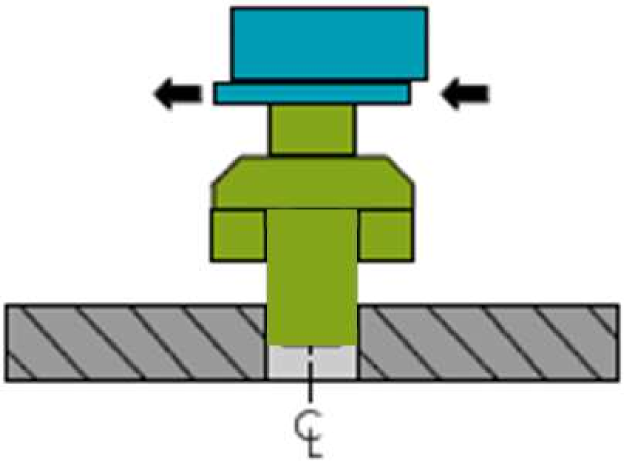


Fig. 9. Compensating device

Thanks to the function of this device, when the pattern enters the connector interface, it aligns itself with the connector and does not cause the appearance of plastic shavings. The improvement was implemented. The control results stabilized, which was reflected in the higher values of PPK and CPK in subsequent SPC controls.

IV. Conclusion

After many measurements and analysis of the results, we can assume that the described method is a necessary tool for verification, as well as a method for locating and proving incorrect control by a control.

It is recommended that these tests be repeated over a period of time - for example 6 months. Due to the wear of the assets parts of the automatic line, over time this can lead to gaps and defects in production.

During the work on the research many improvements were made on the basis of the received and analyzed statistical information from the experiments and this should continue in the future.

Acknowledgment

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