MONITORING OF PRODUCTION QUALITY FOR PLASTIC COMPONENT

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Presented article is focused on monitoring of plastic component production, which is used in automotive industry. Quality of products depends on inspection of production process and thus is essential to use all available control methods. Two methods were used for evaluation of monitoring. First method is verification of measuring system capability, using measuring system analyze. Subsequently was assessed capability of manufacturing system through capability index. Quality indicators were represented by dimensional characteristics of serial produced plastic component. Plastic molding was manufactured using plastic injection technology and is intended for lightening system in vehicles cargo space. All documents for the monitoring capability was provided by LPH Vranov/T, Ltd. Article contain overall assessment of the results and assess the overall capability of measuring and production system.

KEYWORDS

production, measuring system, quality indicators, injection molding, capability

1 INTRODUCTION

Quality and stability of the production processes are notions associated with the regulation procedures. In simple terms, the stability refers to the fact whether the value prescribed during input can be observed during output [Solfronk 2015].

In the very process of the series production of plastic moulded pieces intended especially for automotive industry inevitable is to check several indicators and parameters from material reception through its processing and parameters of injection process up to packing of the final products [Bobek 2016].

In current competition fight in the market the quality is assessed as the preferred effective force focused on acquisition or retaining of the market shares. The effective tool in increasing of the quality is implementation of statistical methods into the process which allow searching for the causes of the process instability, regulate the efficiency and effectiveness of the corrective actions, and stabilize the development of the process by means of which the work quality and productivity increase. It is obvious that the more statistical methods are known, the higher the possibility of analysis and of successful solving of a potential issue is [Skotnicova 2014].

Statistical regulation of the SPC processes is the method of the quality control applying the statistical methods. It is applied to monitor and control the process. The regulation consists of two phases: the first one refers to initial adjustment of specifications of the selected process; the second one represents the case of common process utilization in the production. In comparison to other methods of the quality control the advantage of application of the SPC method rests in preference of timely detection and prevention of occurrence of problematic situations prior to correction of already occurred situations [Dulebova 2014].

Prior to data collection for calculation of capability of indices it is inevitable to check the measurement system of the selected quality character so that the achieved results correctly represent the actual capability of the process [Valicek 2015].

The measurement system is a complete process of collection of data on measurement, i.e. a set of operations, procedures, measuring tools and other equipment, software, personnel applied in assignment of numerical values to the measured features [Michalik 2014]. Assessment of the measurement system quality is performed on the basis of statistical properties: bias in measurement, measurement congruity, measurement repeatability measurement reproducibility, measurement stability, and measurement linearity. The most significant elements of the measurement accuracy are compatibility and bias in measurement [Cidlina 2015].

Capability of the process refers to the process uniformity. Its output extent is usually represented by the process variability. Capability of the process is statistical measure of the inherent variability of the process for the respective characteristics [Skumavc 2016].

The process capability measure has not been agreed on up to present. At times the standard deviation σ or range of quality indicator or their multiple based upon the inherent variability are considered to be the capability measure. Occasionally, it is a combined value of the component induced by the inherent variability and of the component induced by inconsiderable and determinable causes [Kyas 2011].

2 DESCRIPTION OF EXPERIMENT

Following figure (Fig.1) shows analyzed plastic molding used in lightening system in vehicles cargo space. Component was produced from material Dylac R H05, which is ABS material, black colored granulate. Material properties of Dylac R H05 are listed in table below (Tab. 1).

Figure 1. Analyzed plastic molding

Characteristic	Unit	Value
Density	g/cm³	1.06 ± 0.03
Melt-volume flow rate MVR	cm³/10min.	13 – 16
Charpy notched strength	kJ/m²	≥ 10
Charpy impact strength	kJ/m²	≥ 70
Yield strength	MPa	≥ 32
Yield strain	%	≥ 2.4
Tensile strain at break	%	≥ 20
Vicat softening temperature	°C	≥ 90
Water absorption	%	1
Humidity absorption	%	0.3
Melt temperature	°C	230
Mold temperature	°C	60
Drying temperature	°C	80
Max. water content	%	≤ 0.1

Table 1. Material properties of Dylac R H05

Measurements were performed using digital caliper with measuring range 0 – 200 mm and linear altimeter with measuring range 0 – 600 mm.
Measuring consists of two phases:

- measurement for determination of measuring system capability,
- measurement for determination capability of manufacturing system.

Three dimensions were selected for determination capability, which were measured by three operators A, B and C in three cycles. Measured values of dimensions and tolerances are listed in Tab.2.

Dimmension	Value [mm]	Tolerance
1.	76.3	± 0.3
2.	48.6	± 0.1
3.	60.3	± 0.5

Table 2. Measured values

After measuring of selected dimensions, by all three operators, for all moldings can be done calculations of capability coefficients. In subsequence is possible to create graphical dependences of average values.
Repeatability and reproducibility is evaluated for all dimensions which lead to evaluation of measuring system capability. Evaluation of measuring system capability is performed according to repeatability and reproducibility tolerance R&R shown in Tab. 3.

< 10 %	measurement system is acceptable
10 - 30 %	measurement system can be acceptable according to significance of application, measuring tool costs, repair costs
> 30 %	measurement system is unacceptable and it must be improved

Table 3. Assessment criterion of acceptability of the measuring tools

In second phase is capability of manufacturing system evaluated based on capability indexes Cp and Cpk. In this phase were performed fifty measurements of all three dimensions from all molds cavity.

Significance of capability indexes:
For producer: background for probability estimation of occurrence of nonconforming products, preventive and corrective actions, and assessment with regard to the efficacy assessment process stability etc.

For customer: provide evidence that the product was produced in stable production conditions have been complied with and the prescribed quality criteria.
If Cp > 1.33 – process is capable.
If Cpk > 1.33 – pocess is capable and well centered (process is safe).
If Cp < 1.33 – process is not capable.
If Cpk < 1.33 – process is not capable and not well centered (process is not safe).
If Cp = 0 – average of process is located on tolerance boundary.
If Cpk < 0 – average of process is located outside tolerance boundary.

3 EVALUATION

3.1 *MSA - dimmension 1 (76,3 mm ± 0,3)*

Measured values of dimension 1 are listed on Tab. 4. Tolerance R&R is on value 4.96 % which indicates capability of measurement for this dimension. Critical value of this coefficient is set on 10 %. In the fact of this can be stated that measuring system is acceptable.

Repeatability			Reproducibility		
EV	% EV	Tol. %	AV	% AV	Tol. %
0.029	25.15	4.91	0.004	3.41	0.67
Repeatability & Reproducibility			**Part variation**		
R&R	% R&R	Tol. %	PV	% PV	Tol. %
0.029	25.38	4.96	0.11	96.7	18.9
Total part variation				0.117	

Table 4. Final values for dimension 1

Graphical dependence (Fig. 2) represents range and average values for dimension 1. Most precise measurements were performed by operator C and A in range 0.010, measurements performed by operator B were in range 0.010 and in once case 0.030.

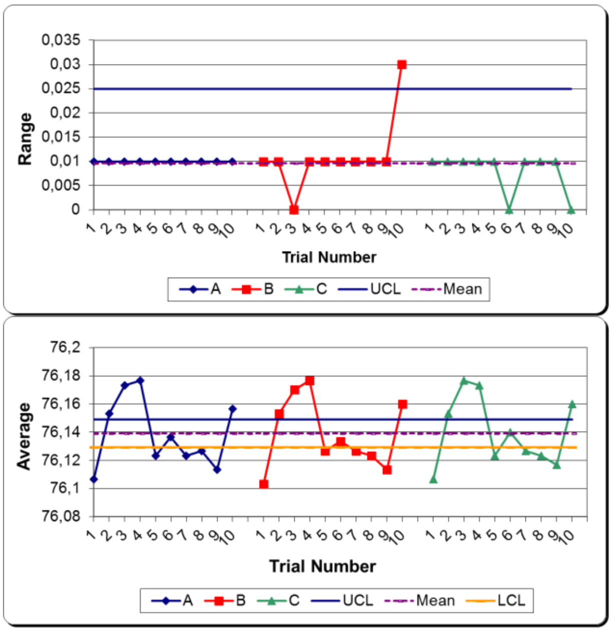


Figure 2. Graph of range and average values for dimension 1

3.2 *MSA – Dimmension 2 (48,6 mm ± 0,1)*

Similar as previous dimension is highlighted in Tab. 5 tolerance of R&R. This tolerance is on value 8.59 %, which means that for this dimension measurement system is acceptable.

Repeatability			Reproducibility		
EV	% EV	Tol. %	AV	% AV	Tol. %
0.016	20.07	8.13	0.005	6.86	2.78
Repeatability & Reproducibility			Part variation		
R&R	% R&R	Tol. %	PV	% PV	Tol. %
0.017	21.2	8.59	0.079	97.72	39.6
Total part variation			0.081		

Table 5. Final values for dimension 2

Graphical dependence (Fig. 3) represents range and average values for dimension 2. Measurements of dimension 2 were not as precise as for dimension 1. Measured values reached higher value of range. For operators A, B is range on value 0.010 and for operator C 0.060. Tolerance limit was not exceeded.

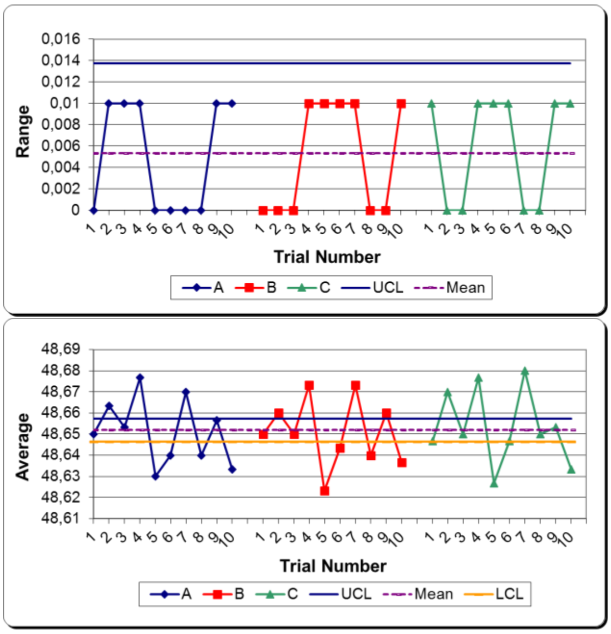


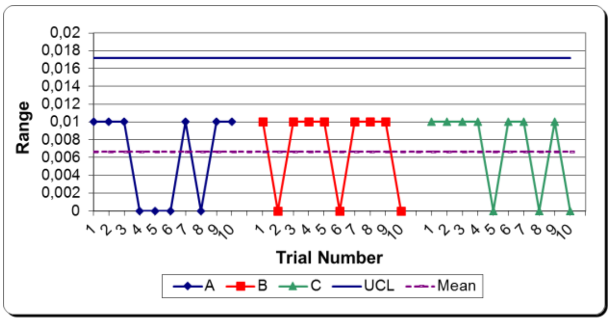
Figure 3. Graph of range and average values for dimension 2

3.3 *MSA – Dimmension 3 (60,3 mm ± 0,5)*

R&R value is on value 21.95 % which results to capability tolerance on value 2.06 %. Capability tolerance under 10 % represents that measurement system for selected dimension is acceptable.

Repeatability			Reproducibility		
EV	% EV	Tol. %	AV	% AV	Tol. %
0.020	21.6	2.03	0.003	3.83	0.36
Repeatability & Reproducibility			Part variation		
R&R	% R&R	Tol. %	PV	% PV	Tol. %
0.020	21.95	2.06	0.091	97.5	9.18
Total part variation			0.094		

Table 6. Final values for dimension 3



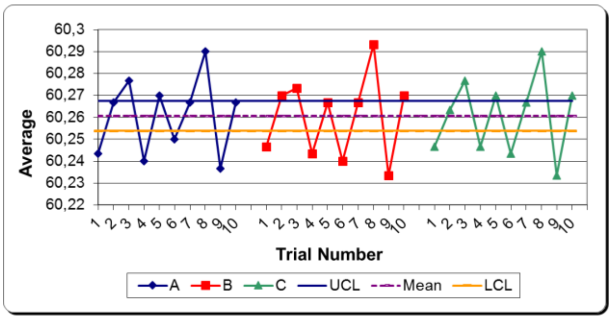


Figure 4. Graph of range and average values for dimension 3

Tolerance limit (UCL) on value 0.017 was not exceded for dimension 3. Most of values lies in range 0.010 (six for operator A and seven for operator B and C).

3.4 *Capability of process - Dimension (76.3 mm ± 0.3)*

Values of capability index for dimension 1 are listed in Tab.7. Cp for dimension 1 is for all cases above value 1.33, which indicates good capability from Cp point of view. Cpk index reaches high value what represents that process is well centered (Fig. 5).

	Max. value	Min. value	Average value	St. dev.	Cp	Cpk
Cavity 1	76.19	76.17	76.180	0.0076	13.229	7.937
Cavity 2	76.23	76.20	76.214	0.0093	10.801	7.705
Cavity 3	76.20	76.18	76.192	0.0080	12.548	8.048
Cavity 4	76.22	76.19	76.207	0.0076	13.210	9.124
Cavity 5	76.23	76.21	76.217	0.0070	14.265	10.328
Cavity 6	76.16	76.14	76.150	0.0077	12.983	6.491

Table 7. Values of capability indexes for dimension 1

Due to similarity between each cavity values, only one histogram for cavity 1 was created (Fig. 5). Graphical representation shows process lies in tolerance limits and is well centered.

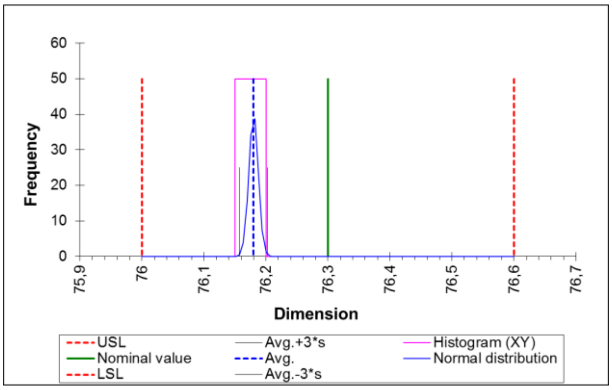


Figure 5. Graphical representation of manufacturing system capability for dimension 1 (cavity 1)

3.5 *Capability of process - Dimmension 2 (48.6 mm ± 0.1)*

Values of capability index for dimension 2 are listed in Tab.8.

	Max. value	Min. value	Average value	St. dev.	Cp	Cpk
Cavity 1	48.7	48.68	48.693	0.0077	4.342	0.295
Cavity 2	48.7	48.68	48.692	0.0080	4.183	0.318
Cavity 3	48.7	48.68	48.693	0.0075	4.440	0.329
Cavity 4	48.7	48.68	48.692	0.0068	4.895	0.411
Cavity 5	48.7	48.68	48.695	0.0065	5.156	0.268
Cavity 6	48.7	48.68	48.691	0.0081	4.124	0.355

Table 8. Values of capability indexes for dimension 2

Cp for dimension 2 is for all cases above value 1.33, which indicates good capability from Cp point of view. Cpk index shows that process is not well centered in relation to nominal value (Fig. 6).
Graphical representation shows that median of measured values is offset from nominal value on the limit USL (which was indicated by Cpk index).

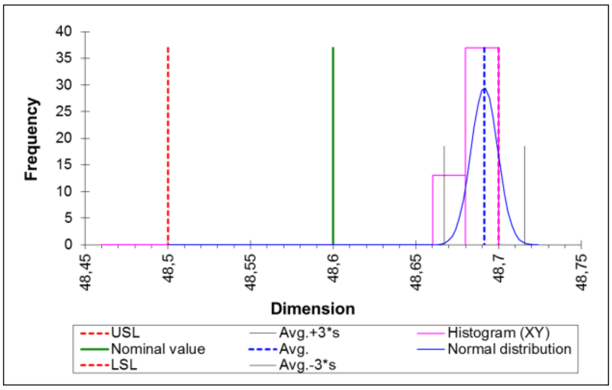


Figure 6. Graphical representation of manufacturing system capability for dimension 2 (cavity 6)

3.6 Capability of process - Dimension 3 (60.3 mm ± 0.5)

Cp index is above 1.33 which indicates good capability of process. Cpk index is also above 1.33. In the fact of this can be stated that process is capable and well centered.

	Max. value	Min. value	Average value	St. dev.	Cp	Cpk
Cavity 1	60.34	60.33	60.335	0.0050	33.025	30.700
Cavity 2	60.31	60.29	60.298	0.0083	20.193	20.120
Cavity 3	60.31	60.30	60.307	0.0045	36.747	36.217
Cavity 4	60.37	60.36	60.364	0.0050	33.429	29.137
Cavity 5	60.25	60.24	60.244	0.0050	33.429	29.698
Cavity 6	60.21	60.19	60.199	0.0079	21.125	16.858

Table 8. Values of capability indexes for dimension 3

Similar capability indexes causes proximity for values in histogram. Normal distribution lies in narrow interval near nominal value Fig. 7.

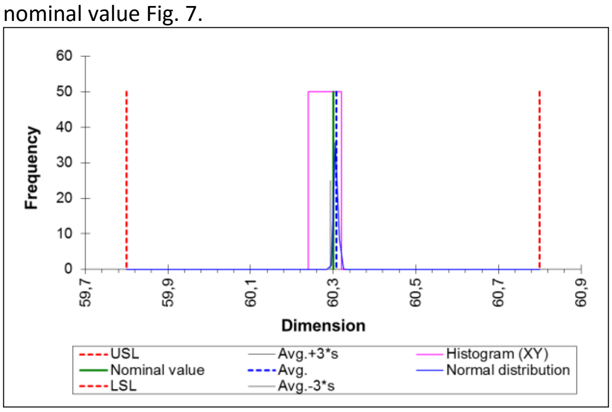


Figure 7. Graphical representation of manufacturing system capability for dimension 3 (cavity 3)

4 CONCLUSION

Measurements from three dimension of the molding manufactured in LPH Vranov n/T Ltd. were numerically and graphically evaluated. In first part evaluation of measurement system capability was performed. Each dimension complied for tolerations repeatability and reproducibility (for all cases lower than 10 %). Subsequently was evaluated capability of manufacturing process. For this capability compiled all dimensions, with exception of dimension 48.6 mm ± 0.1. In this case according to Cp was system capable with low range of values. Verification using Cpk index proved that process is not well centered, which leads to examining and rectification of system.

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REFERENCES

[Bobek 2016] Bobek, J. et al. New silane and MAPP coupling agents as natural composites production systems improvement, Key Engineering Materials, 2016, Vol. 669, pp. 52-59. ISSN 1013-9826.

[Cidlina 2015] Cidlina, J., Müller, M. Influence of adhesive bonded surface treatment of alloy AlCu4Mg and increased environmental temperature on adhesive bond strength. Manufacturing Technology, 2015, Vol. 15, No. 4, pp. 520-526. ISSN 1213-2489.

[Dulebova 2014] Dulebova, L. et al. Characterization of mechanical and thermal properties of pp/mineral composites. Advanced Materials Research, 2014, Vol. 1025-1026, pp. 241-245. ISSN 1022-6680.

[Kyas 2011] Kyas, K. et al. Simulation of rubber injection molding process. Chemicke Listy, 2011, Vol. 105, No. 15 SPEC. ISSUE, pp. s354-s356. ISSN 0009-2770.

[Michalik 2014] Michalik, P. et al. Monitoring surface roughness of thin-walled components from steel C45 machining down and up milling. Measurement, 2014, Vol. 58, pp. 416-428. ISSN 0263-2241.

[Skotnicova 2014] Skotnicova, K. et al. The effect of crystallization conditions on tantalum distribution in molybdenum and tungsten during electron beam zone melting. Metalurgija, 2014, Vol. 53, No. 2, pp. 209-211. ISSN 0543-5846.

[Skumavc 2016] Skumavc, A. et al. Thermal fatigue study of tungsten alloy WNi28Fe15 cladded on AISI H13 hot work tool steel. Surface and Coatings Technology, 2016, Vol. 285, pp. 304-311. ISSN 0257-8972.

[Solfronk 2015] Solfronk, P. et al. Influence of deformation on the damage of zn-mg based protective coating. Materials Science Forum, 2015, Vol. 818, pp. 57-60. ISSN 0255-5476.

[Valicek 2015] Valicek, J. et al. Quantifying the Mechanical Properties of Materials and the Process of Elastic-Plastic Deformation under External Stress on Material. Materials, 2015, Vol. 8, No. 11, pp. 7401-7422. ISSN 1996-1944.

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