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SHEWHART CONTROL CHARTS APPLICATION BY CONTROL OF INJECTION PRODUCTS

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ABSTRACT
The paper deals with possibilities of using the statistical methods at injection moulding. Shewhart control charts are one of these methods. The Shewhart control charts have three main functions: to determine whether a process is under control, to help achieve and maintain statistical control, especially in avoiding overadjustment, and to evaluate continuous improvement efforts. These Shewhart control charts were used at on specimen from PE, PA 6, PMMA, which made by injection processing. Injection moulding represents the most important process for manufacturing plastic parts. It is suitable for mass producing articles, since raw material can be converted into a moulding by a single procedure. In most cases finishing operations are not necessary. The experiment results were evaluated and processed into the graph.
Key words: injkection moulding, polymer technology, statistical methods.

1. INTRODUCTION
1.1. Plastics and processing of plastics by injection
Injection moulding represents the most important process for manufacturing plastic parts. It is suitable for mass producing articles, since raw material can be converted into a moulding by a single procedure. In most cases finishing operations are not necessary.
An important advantage of injection moulding is that with it we can make complex geometries in one production step in an automated process. Typical injection mouldings can be found everywhere in daily life; examples include toys, automotive parts, household articles, and consumer electronics goods.
Injection moulding is complicated thermomechanical treatment of moulding. Influences applied on this process:

- Raw material from which the part is produced
- Production cycle, primarily injection moulding machine and others components; the melt and her transport into the mould is prepared with the help of these components
- Mould as a principal implement for injection moulding

These factors influence product manufacture quality.

1.2. Quality control in production

The Shewhart control chart has three main functions: to determine whether a process is under control, to help achieve and maintain statistical control, especially in avoiding overadjustment, and to evaluate continuous improvement efforts.
The control chart can be used to demonstrate that the process has no systematic disturbances and trends. If there is a systematic disturbance, such as mould and machine wear, or different batches of raw material, the mean value of quality is outside the range of tolerance for a longer period. Setting up a control chart requires sampling of a predetermined number of processed parts from the process. From the se samples, a mean value and a deviation parameter (for instance, the average and the standard deviation) are calculated. These parameters are plotted over time.
Naturally the parameter under consideration depends on the application. Usually dimensions of the part are the quality parameters, because the mouldings are assembled with other parts. In some cases it is sufficient to measure the part weight because it correlates with the part dimensions; the weight can be measured automatically and directly after demoulding, before the part has cooled. In other cases mechanical properties (such as burst pressure for a hollow part, or maximum external loading) or optical properties (such as color or gloss) may be chosen as quality parameters. The principle of the procedure in the following statistics is always the same, so the values may be dimension, weight, gloss, or any other.

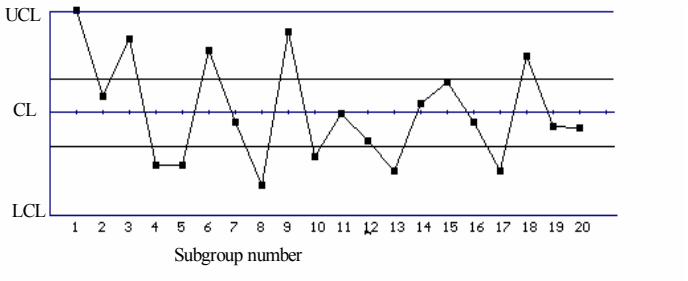

Figure 1. Shewhart control chart

Figure 1 is an example of a Shewhart control chart, in this case an X-bar – R chart. The horizontal lines indicate the control limits, which are calculated according to certain specifications and define the limits of the natural variation of the process. A process is said to be under statistical control if these values vary only little and stay within tolerances. If the process is under statistical control it is possible to evaluate the machine process capability.
Shewhart control chart show how the average of a set of measurements and the range of the measurements vary with time, see figure XY. The average of asset of measurements is often called the mean and represented by the symbol xq. The range is the difference between the largest and smallest measurement, it is represented by symbol R.

2. THE EXPERIMENT

The specimens from PMMA, PE-HD liten a PA 6, were used for following experiment. Surface hardness was measured on these specimens. Measuring was taken with ČSN EN ISO 868 on the same place of the specimen. Measuring was carried out by means of hardness tester Shore BS 61 – Shore D. Mountable weight exerts on test specimen at measuring by force 50 N. Loading time was used 3 s.
Measuring data was processed by means of expressions for Shewhart control chart.
In table due to space limit measured data are presented only for PMMA material.

2.1. Processing results for PMMA

Table 1 and figures 1 and 2 shows processing measuring data for specimens from PMMA.

Table 1. Measuring data of specimens from PMMA

Subgroup number	1	2	3	4	5	6	7	8	9	10
x1	90,9	88,5	89,9	89,1	88,7	89,7	89,1	88,7	88,4	89,3
x2	90,9	89,0	90,0	89,9	89,4	88,8	88,5	88,6	88,9	89,2
x3	89,7	88,2	89,8	89,4	89,5	89,0	89,3	89,0	89,6	89,9
x4	89,6	90,0	89,0	89,2	88,8	88,6	89,7	89,3	90,0	89,5
x5	89,1	89,6	88,2	88,9	90,6	88,4	89,6	88,8	89,3	89,8
S	450,2	445,3	446,9	446,5	447,0	444,5	446,2	444,4	446,2	447,7
xq	90,04	89,06	89,38	89,30	89,40	88,90	89,24	88,88	89,24	89,54
R	1,8	1,8	1,8	1,0	1,9	1,3	1,2	0,7	1,6	0,7
Subgroup number	11	12	13	14	15	16	17	18	19	20
x1	89,1	89,4	89,5	89,7	90,0	90,1	90,4	90,0	90,0	90,2
x2	90,0	89,2	89,0	89,8	89,7	90,0	89,3	89,6	89,8	89,5
x3	89,0	90,4	88,8	89,5	89,4	89,5	88,8	89,8	89,8	89,9
x4	89,9	89,8	89,6	90,1	89,2	89,0	89,0	89,7	89,7	90,1
x5	89,6	90,0	90,0	89,4	89,7	89,9	89,4	89,8	89,9	90,3
S	447,6	448,8	446,9	448,5	448,0	448,5	446,9	448,9	449,2	450,0
xq	89,52	89,76	89,38	89,70	89,60	89,70	89,38	89,78	89,84	90,00
R	1,0	1,2	1,2	0,7	0,8	1,1	1,6	0,4	0,3	0,8

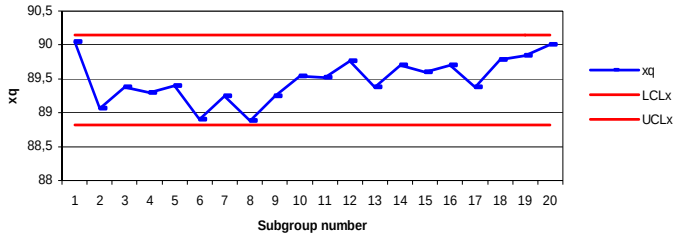

Figure 2. Graph xq for specimens from PMMA

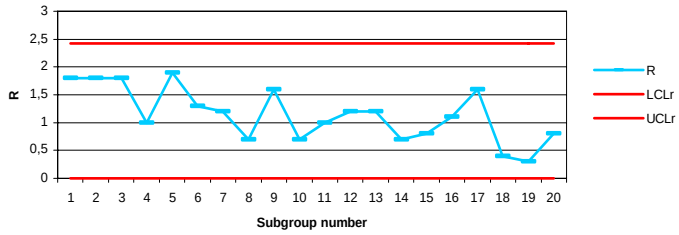

Figure 3. Graph R for specimens from PMMA

2.2. Processing results for PE

Figures 3 and 4 shows processing measuring data for specimens from PE.

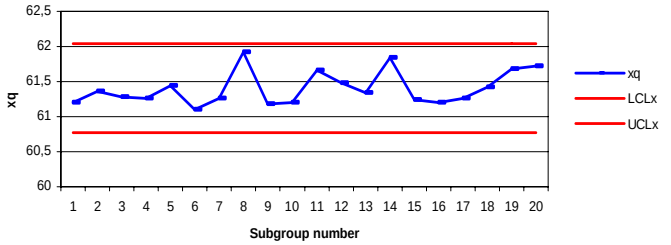

Figure 4. Graph xq for specimens from PE

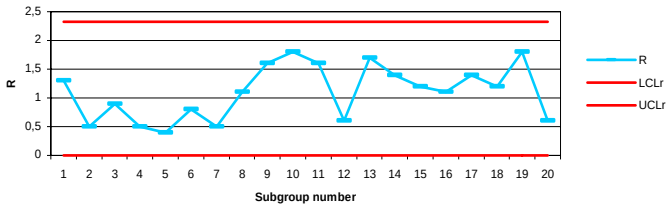

Figure 5: Graph R for specimens from PE

2.3. Processing results for PA 6

Figures 5 and 6 shows processing measuring data for specimens from PA 6.

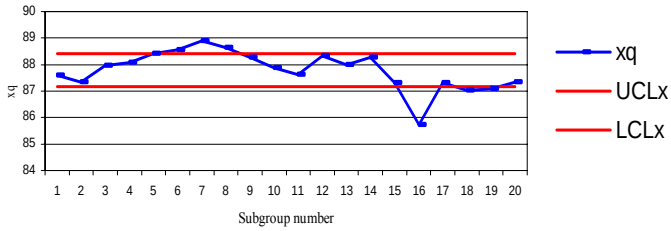

Figure 6. Graph xq for specimens from PA 6

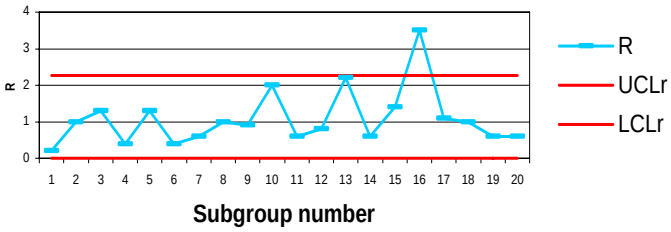

Figure 7. Graph R for specimens from PA 6

3. CONCLUSION

The value of calculated selective characteristics of various subgroups were plotted into Shewhart charts. Graphs were made for materials: PMMA, PE and PA 6. Control limits determinate zones in which the values of calculated selective characteristics of subgroups are located with predetermined probability. In case PMMA and PE all resulting values of calculated selective characteristics of subgroups are inside of control limits. It means, this process is influenced by only accidental sources variability of the process in the given time interval.

Another situation is at specimens from PA 6 – some values of calculated selective characteristics aren't inside control limits. It means, systematic sources begin to influence the technology process together with accidental sources variability. The systematic sources are caused especially by wrong setting of processing parameters (injection temperature, pressure, time delay).

In the end it is possible to state that the quality of moulding is difficult to assure. The quality is influenced by not only processing parameters but also by the kind of plastic material, by the shape of components, by the mould and its quality.

4. REFERENCES

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