DESIGN OF PLANED EXPERIMENTS TO APPRAISAL OF QUALITY PARAMETERS BY INJECTION MOULDING

JOZEF DOBRÁNSKY[1], DUŠAN MANDUĽÁK[2]

Abstract: Paper deals with design of planed experiments to appraisal of quality parameters by injection moulding. In this paper is represented merit of injection moulding technology. Specimen using for this planed experiment is mowing-machine safety cover. It was chosen three technological parameters from all technological parameters which affected in the production process. Also it was chosen four quality parameters which are needed to observe. Next was created planed experiment to observation of three technological parameters to three quality parameters.

Keywords: experiment, plastics, pressure, injection, speed, volume, diameter, weight

1. INTRODUCTION

It would be difficult to imagine our modern world without plastics. Today they are an integral part of everyone's lifestyle with application varying from commonplace domestic articles to sophisticated scientific and medical instruments. Injection moulding is a major processing technique for converting thermoplastic materials. The basic concept of injection moulding is the ability of a thermoplastic material to be softened by heating, formed under pressure, and hardened by cooling.

Task of planed experiments is filling up model of real situations of injection moulding technological processes by specific numbers. At the practice don't affect these technological parameters always only by additive style, but together at the cross interaction. Analyzed of this model enabled factor experiments, by those are attempts realized for all level combinations of appraisal factors.

[1] *Ing., PhD., TU Košice, Faculty of manufacturing technologies with a seat in Prešov,dobransky.jozef@fvt.sk*
[2] *Ing., LPH Vranov nad Topľou, dmandulak@lph.sk*

2. INJECTION MOULDING

Injection molding is a major processing technique for converting thermoplastic materials. The basic concept of injection molding (Fig. 1) is the ability of a thermoplastic material to be softened by heating, formed under pressure and hardened by cooling. In a reciprocating screw injection molding machine, granular material (the plastic resin) is fed from hopper (feeding device) into one end of the cylinder (the melting device). It is heated and melted (plasticized or plasticated), and it is forced out the other end of the cylinder (while still melted) through a nozzle (injection) into a relatively cool mold (cooling), held closed by the clamping mechanism. The melt cools and hardens (cures) until it is set up.

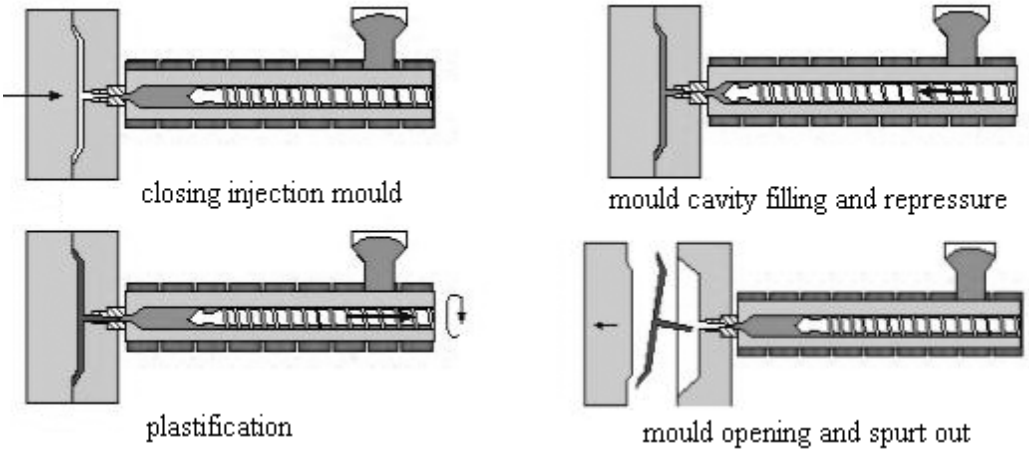
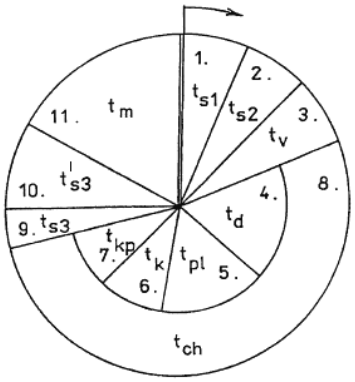


Fig. 1. Basic concept of injection moulding

Theoretical we can injection cycle divide into some basic parts, which is represented on figure 2.



t_{s1} – closing mould;
t_{s2} – roll in melting unit to mould,;
t_v – mould cavity filling;
t_d – repressure;
t_{pl} – plastification,
t_k – melting unit move out from mould;
t_{kp} – unit abidance in displaced;
t_{ch} – spurt cooling;
t_{s3} – mould open;
t_{s3}' - spurt removal;
t_m – manipulation time.

Fig. 2. Distribution time of injection (working) cycle

3. INJECTION MOULDING MACHINES

For injection moulding are using injection machines of different types with different technical parameters which are produced by different producers. Injection moulding machine consists of five basic parts:

- injection unit;
- mould;
- closing unit;
- operating system;
- hydraulic system and screw drive.

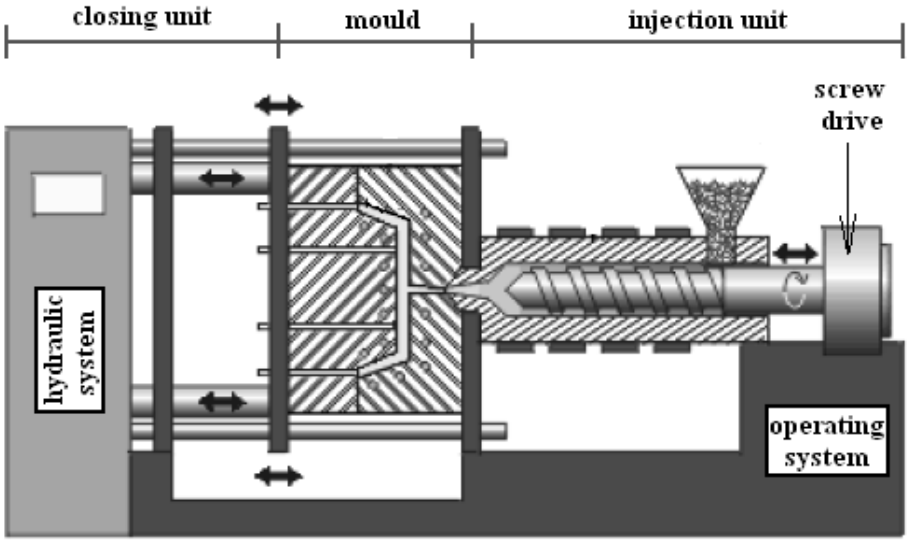


Fig. 3. Basic parts of injection moulding machine

4. PLANNED EXPERIMENTS THEORY

From theoretical analyze is obvious that technological process of injection moulding is a complex process to which come into technological parameters actuated in their relative interaction by different levels on quality parameters of finished product. Evaluation of technological parameters and evaluation to their properties is complex process which is consisting of each other consequential steps. Every of them affected quantum parameters which has effect to result and by classic type of evaluation could by induce doubts at final results.

Task of every research work is decrease time and financial expensiveness on acceptable level what needed solid preparation of experiments. By experimental work is possible to proceed with classical style when is by constant conditions changed level always only one value (factor) and from experiment result is obvious that examination value affected changes and eventually what style.

A result of experiments is not often uniform and in this case is needed to repeat measurement and for evaluation of result (response) use some statistics characteristic as mean or median. We can predict that some observed values are incidental character and in this case is needed to use mathematical statistic mechanism.

Disadvantages as especially time seriousness and financial loading by classical experimental solution markedly reduced using of planned experiments. Its advantage consists in minimal costs on one experiment, ortogonality and from this consequent simplified calculation. Based on planned experiments is possible to evaluate also interaction effect of individual factors.

Independent current parameters which has effect to process are called factors $x_1, x_2, \ldots, x_k$. Quantity of attempts by full factor experiments are represents by relation:

$$N = \lambda^k \tag{1}$$

where: λ – amount of level; k – amount of factors.

5. DESIGNED PLANNED EXPERIMENT

Based on analyze of all technological parameters was selected three technological parameters:

- injection pressure p_4
- injection speed v_4
- switch point V_4 (a point by which is injection pressure running to repressure).

Equally based on analyze of all quality parameters was selected four quality parameters (Fig. 4) which are needed to observe by production of this product:

- diameter d_{4A}
- diameter d_{4B}
- length of centre line between two diameters l_4
- total weight m_4

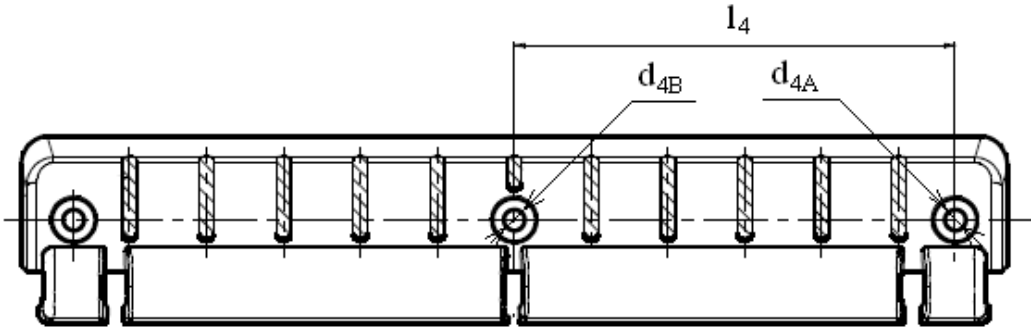


Fig. 4. Observed quality parameters

By statistical evaluation of factors was used three-level planned experiment type of 3^3. By 27 attempts with 5 repetitions was evaluated effect of factors to select quality parameters. Table 1 shows encoding of factors by levels with additional actual values.

Tab. 1. **Encoding of factors by levels with additional actual values**

Factors				**Factor values**		
N.of f.	marking	name	dimension	-1	0	1
1	x_1	injection speed (v_4)	cm^3/s	40	113	200
2	x_2	injection pressure (p_4)	MPa	80	93,5	107
3	x_3	switch point (V_4)	cm^3	3	21,5	40

Tab. 2. **Encoded conditions of attempts**

Num. of attempt	**Encoded conditions of attempts**			**Num. of attempt**	**Encoded conditions of attempts**		
	x_1	x_2	x_3		x_1	x_2	x_3
1	-1	-1	-1	15	0	0	1
2	-1	-1	0	16	0	1	-1
3	-1	-1	1	17	0	1	0
4	-1	0	-1	18	0	1	1
5	-1	0	0	19	1	-1	-1
6	-1	0	1	20	1	-1	0
7	-1	1	-1	21	1	-1	1
8	-1	1	0	22	1	0	-1
9	-1	1	1	23	1	0	0
10	0	-1	-1	24	1	0	1
11	0	-1	0	25	1	1	-1
12	0	-1	0	26	1	1	0
13	0	0	-1	27	1	1	1
14	0	0	0				

6. CONCLUSION

Paper deals with design of planed experiment to appraisal of quality parameters by injection molding. First it was chosen three technological parameters from all technological parameters which affected in the production process. Also it was chosen four quality parameters which are needed to observe. Based on created planned experiment is possible to make full experiment to observation of technological parameters and its effect on quality parameters. Based on these planned experiment will made graphs of influence of technological parameters to product quality parameters by injection molding. It will be three types of graphs: Pareto graphs, graphs of Marginals diameters and 3D graphs of influence of technological parameters to product quality parameters.

REFERENCES

[1]. **Campo, A.,** *The complete part design handbook: For injection molding of thermoplastics*, Hanser Gardner Publications, Cincinnati, 2006.

[2]. **Dobransky, J.,** *Observation of production process capacity by injection moulding*, In: Scientific bulletin of International multidisciplinary conference, North University of Baia Mare, Romania, 2007.

[3]. **Harper, Ch., Petrie, E.,** *Plastics materials and processes*, John Wiley and sons, New Jersey, 2003.