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DYNAMIC OF TAKING OUT MOLDING PARTS AT INJECTION MOLDING

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Most plastic parts used in automobile production are manufactured by injection molding. Their quality depends also on taking out molding and on the manipulators for it. Task of this contribution is to theoretically describe a transport of molding at taking out after injection molding in relation on its regulation. The following quantities are derived at it: the transition characteristic of the taking out system, the blocking diagram of taking out molding regulation, the amplitude and phase characteristic and the transition characteristic of action quantity at taking out molding regulation.

Key words: transport, processing plastics, manipulator, theoretically describe

Dinamička izradba odljevaka tlačnim ljevanjem. Cilj ovog rada je teorijski opis transporta odljevaka od plastike poslije tlačnog ljevanja relacijom i njihovom regulacijom. Sljedeće vrijednosti su izvedene: tranzicijski karakter ustrojnog sustava, blok dijagrama izradbe regulacije odljevka, amplituda i fazna karakteristika i tranzicijska karakteristika i kvantiteta udeđaja kod ustroja ljevačke regulacije.

Ključne riječi: transport, izradba plastike, manipulator, teorijski osvrt

INTRODUCTION

Quality of the molding at injection molding technology depends on taking out molding and on the manipulators for it [1-3]. At injection molding of plastics for automation of taking out the molding the manipulators of various design especially mechanical one are used according to Figure 1 [4-6]. With regards on an assumption of the taking out the molding regulation it is necessary to perform the description of the manipulator arm motion by motion equations and their analysis by the linear theory of regulation [7].

MOTION EQUATIONS AND THEIR ANALYSIS

The moment of the manipulator arm M is equalled to the product of the moment of inertia J and the angle acceleration ε plus the moment of friction resistance in the bearing for arm turning M_{fr}.

$$M = J \cdot \varepsilon + M_{fr} \tag{1}$$

where it is:

M - the moment of the manipulator /Nm, J - the moment of inertia of the manipulator arm turning masses /kg·m^2, ε - the angle acceleration of the manipulator arm /s^{-2}, M_{fr} – the moment of friction resistance in the manipulator arm bearing /Nm.

It is possible to express the moment of friction resistance in the manipulator arm bearing

$$M_{fr} = k_1 \cdot \omega + \tag{2}$$

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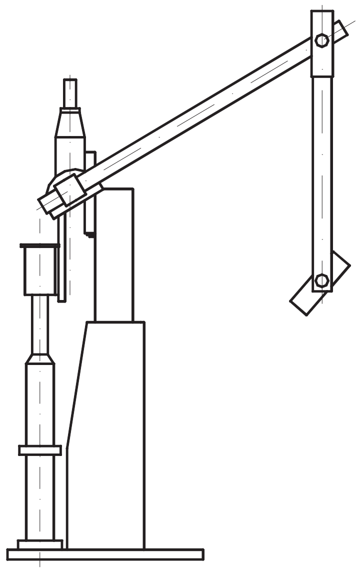

Figure 1 Diagrammatic sketch of the manipu-lator of taking out the moldings

where it is:

k_1 – constant /Nm·s/, ω – angle velocity of the manipulator arm /s^{-1}/

The moment of the manipulator is proportional of the throttle opening n

$$M = k_2 \cdot n \tag{3}$$

where it is:

k_2 – constant /Nm/divisions/, n – throttle opening [divisions].

The angle acceleration ε is derivate of the angle velocity ω according to time t

$$\varepsilon = \frac{d\omega}{dt} \tag{4}$$

where it is t – time /s/.

After substitute the equation (1) is

$$k_2 n = J\frac{d\omega}{dt} + k_1 \omega J \tag{5}$$

Transmission of the system

After the adaption on an operator form we get the transmission S as the ratio of the inlet quantity image Ω (p) and outlet quantity one N (p)

$$\mathrm{S} = \frac{\Omega(\mathrm{p})}{\mathrm{N(p)}} = \frac{\mathrm{k}_2}{\mathrm{k}_1}\left(1 - \frac{\mathrm{p}}{\frac{\mathrm{k}_1}{\mathrm{J}} + \mathrm{P}}\right) \tag{6}$$

The original to the transmission is the transition characteristic

$$\omega = \frac{\mathrm{k}_2}{\mathrm{k}_1}\left(1 - \mathrm{e}^{-\frac{\mathrm{k}_1}{\mathrm{J}}\mathrm{t}}\right) \tag{7}$$

and the time constant:

$$t_0 = \frac{1}{\mathrm{k}_1} \tag{8}$$

The transition characteristic is ilustrated on Figure 2.

If the jump of the inlet quantity is not unit but it acquires certain values of the divisions n_1 the course of the angle velocity of the arm manipulator ω is on Figure 3.

REGULATION OF THE SYSTEM

For control of the angle velocity of the manipulator arm ω it is possible to derive the reaction coupling from the motion of the arm. It is illustrated by the blocking diagram on Figure 4 at assumption of the regulator application of the regulator.

Then it is possible to derive the transmission of the regulation system. For the transmission of the action quantity

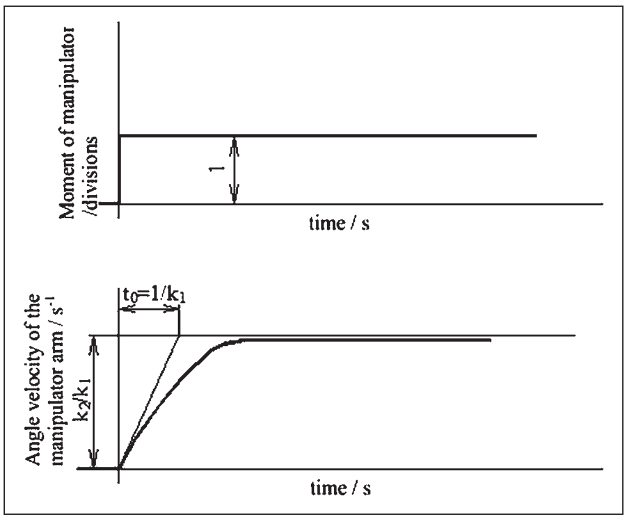

Figure 2 The transition characteristic of the system

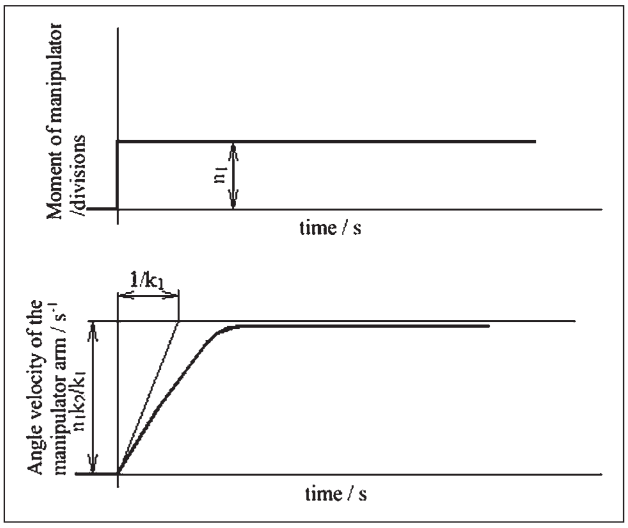

Figure 3 The time course of the angle velocity of the manipulator arm ω - M (divisions)

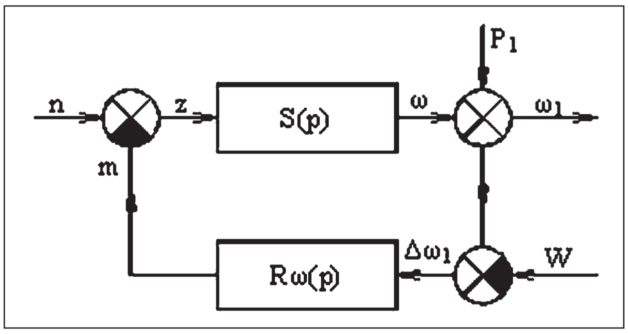

Figure 4 Blocking diagram of taking out molding regulation

$$F\omega = \frac{\Omega}{N} = \frac{S}{1 + R\omega S} \tag{9}$$

The transmission of the defect

$$F_p = \frac{\Omega}{p_1} = \frac{1}{1 + R\omega S} \tag{10}$$

The transmission of the control

$$F_W = \frac{\Omega}{W} = \frac{R\omega S}{1 + R\omega S} \tag{11}$$

We choose the regulator PI with the transmission

$$R\omega = P\left(1 + \frac{1}{pT_i}\right) \tag{12}$$

where it is:

P - the proportional constant of the regulator, T_i – the integration time constant of the regulator / s

The transmission of the action quantity is

$$F\omega = \frac{P}{\frac{p}{T_i} + \frac{k_1 + pk_2}{k_2} + \frac{1}{k_2}p^2} \tag{13}$$

Because all coefficients of the denominator are positive the circumference is stable. By reduction the coefficients of the denominator and derivations of the members according to p it is possible to come to the condition of circumference aperiodicity.

$$\left(\frac{k_1 + pk_2}{J}\right)^2 \geq 1 \tag{14}$$

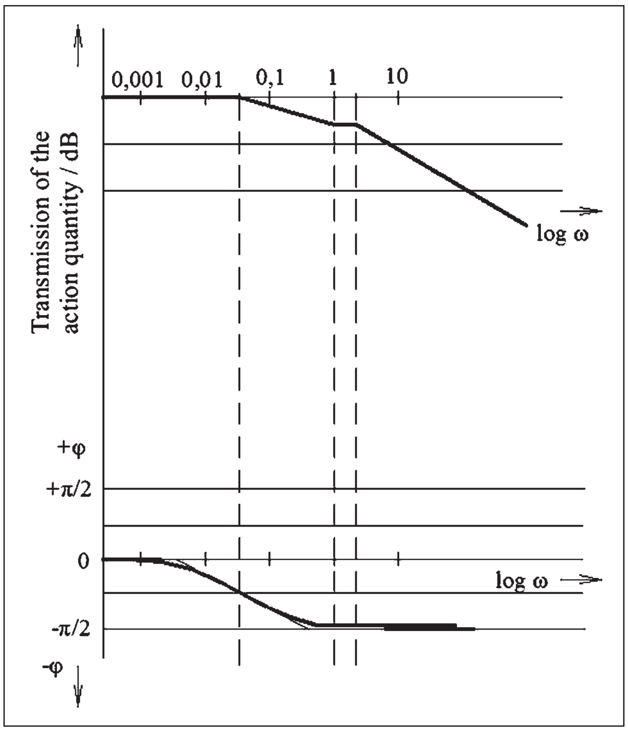

Figure 5 The amplitude and phase characteris-tic of the action quantity at regulation

If it is possible to neglect k_1 against k_2p then

$$k_2 > \frac{J}{p} \tag{15}$$

At fulfilling the conditions (14) respectively (15) the circumference is stable aperiodic. In opposite case it is stable damped oscillating. The amplitude and phase characteristic of the action quantity is on Figure 5 and the transition characteristic on Figure 6.

The transition of the defect is

$$Fp_1 = \frac{\frac{k_1}{J}p + p^2}{\frac{pk_2}{T_i J} + \frac{k_1 + pk_2}{J}p + p^2} \tag{16}$$

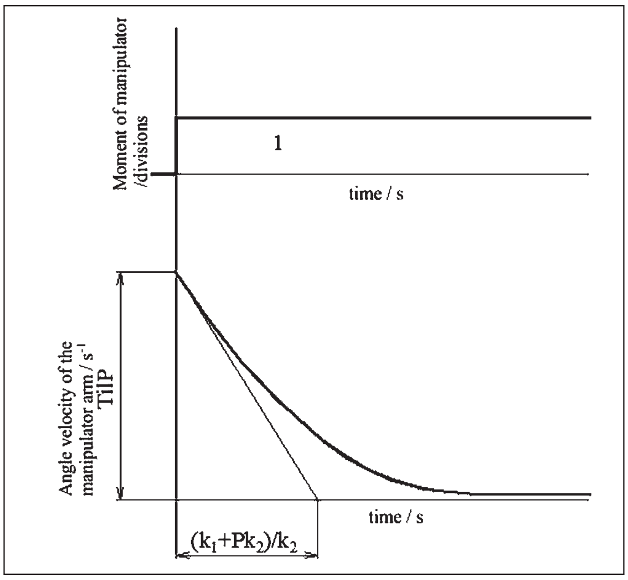

Figure 6 The transition characteristic of the action quantity at regulation

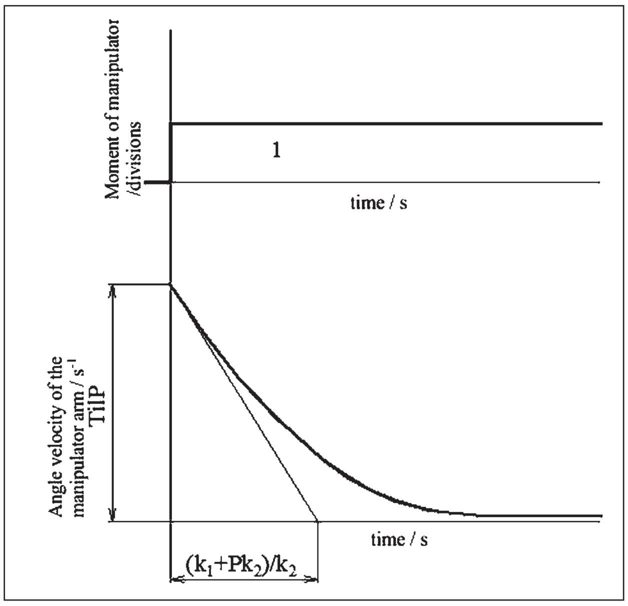

Figure 7 The amplitude and phase characteristic of the defect at regulation

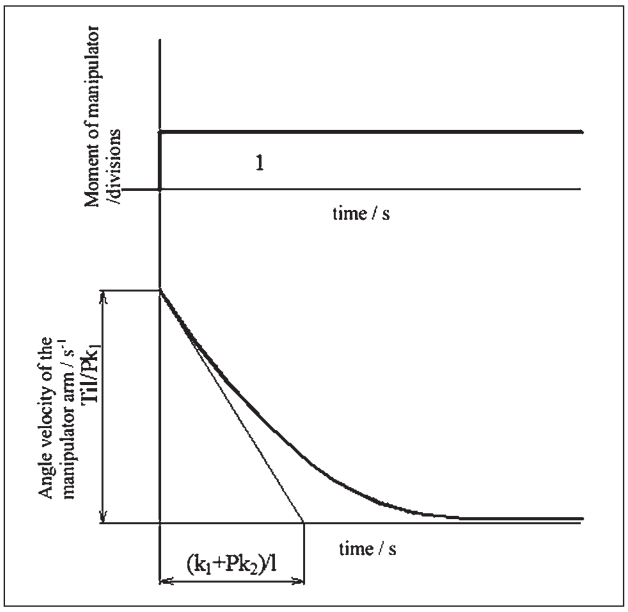

Figure 8 The transition characteristic of the defect at regulation

The amplitude and phase characteristic of the defect is on Figure 7 and transition characteristic of the defect on Figure 8.

The transition of the control

$$Fw = \frac{\frac{pk_2}{T_i J}\left(1 + pT_i\right)}{\frac{pk_2}{T_i J} + \frac{k_1 + pk_2}{J}p + p^2} \tag{17}$$

The amplitude and phase characteristic is for p = 1 and Ti = 1 analogous as at the action quantity. The transition characteristic is on Figure 9.

CONCLUSION

The regulation of manipulator arm motion at taking out molding at injection molding technology is impor-

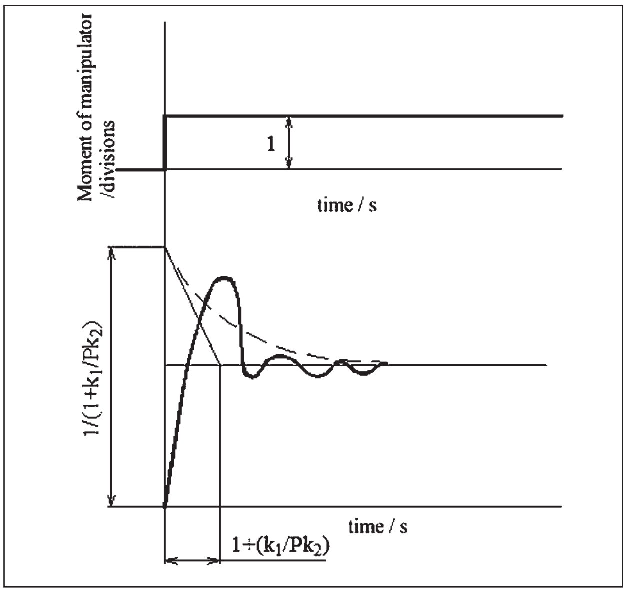

Figure 9 Transition characteristic of control at regulation

tant. The characteristic of taking out molding system and transmission of action quality derived by the linear theory of regulation show that the circumference is stable aperiodic. These properties are an assumption for various industrial applications with robots in the plastic industry [8-10] and they are important for dynamic production and increasing productivity.

REFERENCES

[1] Panda, A. et al., Vývoj, výroba a overenie nových výrobkov pre automobilový priemysel - 1. časť, FVT TU, Prešov, 2009.

[2] Běhálek, L., Properties of injection parts from SMA regranulats, Acta Mechanica Slovaca, 7, (2008), 39-44.

[3] Paško, J., Pavlenko, S., Gašpár, Š., Robotic systems and their usage for medical purposes, Scientific Bulletin, 23, C (2009), 277-282.

[4] Novák – Marcinčin, J., et al., Application of the virtual reality modelling language to computer aided robot control system Roans, Strojarstvo, 52, (2010) 2, 227-232.

[5] Brychta, J., Čep, R., Nováková, J., Petřkovská, L., Technologie II, VŠB TU, Ostrava, 2007.

[6] Nová, J. Nováková, I. Bradáč, J., Technologie I, TU Liberec, 2006.

[7] Ahn, D., G., Applications of laser assisted metal rapid tooling process to manufacture of molding & forming tools - state of the art, International Journal of Precision Engineering and Manufacturing, 12, (2011) 5, 925-938.

[8] Monka, P., Monková, K., Process plans design in relation to increasing of production efficiently, Scientific Bulletin, 23, C (2009), 239-244.

[9] Greškovič, F. et al., Nástroje na spracovanie plastov - vstrekovacie formy, SjF TU, Košice, 2010.

[10] Kreheľ, R., Systém pre bezkontaktnú optickú identifikáciu, Automatizace, 50, (2007) 6, 407-409.

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