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INTERACTIONS BETWEEN PREDICT RELATIONS DURING CAVITY FILLING PROCESS

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ABSTRACT:
The presented contribution describes experience with numerical modelling of the process control of die cavity filling in pressure die casting is described by relations for laminar and turbulent flow and simulating in transparent dies. Interaction of derived differential equations that the circuit of the process is stable aperiodical or damped oscilating favourable for control is the main objective.

KEY WORDS:
die casting, processing parameters, turbulent and laminar flow, transient characteristic

1.INTRODUCTION

Prediction of the theoretical knowledge about die cavity filling in pressure die casting, its relations for laminar and turbulent flow are created in the presentation.

Experimental part of the presentation rewiews selected results from the progress of die cavity filling, speed and pressure in pressure die cavity casting and possibility of control which are important for die casting quality.

2. THEORETICAL ANALYSIS OF PROBLEM. MATHEMATICAL MODEL

2.1 FLOW SPEED

Melting metal flow at die cavity filling in pressure die casting depends on inlet speed, viscosity and surface tension of melting metal.

From laminar flow

$$\frac{p}{sg} = \frac{32\nu v l}{g d^2} + \frac{1 dv}{g dt} + \frac{4\delta}{d}\cos\vartheta + \frac{p_{0x}}{sg} + \frac{p_q}{sg} \tag{1}$$

$$\frac{v^2}{2g}\,(1+\zeta) \tag{1.1}$$

According to [2] the melting metal viscosity is dependent on the melting metal temperature fall square.

The relation for turbulent flow is similar as for laminar one but the first term on the right is in (1.1), where is ζ - the hydraulic resistance coefficient.

From literature [3,6] it is possible to simulate the pressure die casting of aluminium alloys with water in transparent dies. It enables filming the flow progress.

At the pressing piston speed 1 ms-1 and the flow speed 20 ms^{-1} the water flow was splinted off the die. The flow front according to figure 1 was spread as a mushroom. The symmetry of this shape is very sensitive on regularity and roughness of the die inlet.

The flow front bumps on oppposite die cavity side.Then it was divided in two flows returning to the die inlet and closing two air volumes.

To predict relations at the turbulent flow we can neglect pax and σ and mark the difference p – pg as p1 then can be expressed as :

$$P_1 = \frac{v^2}{2}\,\zeta s + als \qquad (1.2)$$

After approximating v² = kv and arrangement we get the transfer

$$S_v = \frac{V(p)}{\frac{1}{\Xi(p)}} = \frac{2p_1}{sk}\left(1 - \frac{p}{\frac{k\xi s}{2l} + p}\right) \qquad (2)$$

We considering ζ = ζaverage as a constant.

The original to the transfer is the transient characteristic

$$V = \frac{2p_1}{sk}\left[1 - \exp\left(-\frac{ks\xi_{average}}{2l}\,t\right)\right] \qquad (2.1)$$

and the time constant

$$t_o = \frac{2l}{ks\xi_{average}} \qquad (2.2)$$

and for real conditions in working

$$t_o = \frac{\Delta v}{a} \qquad (2.3)$$

when Δ v = 0,4 ms-1, a = 50 ms-2 then t0 = 0,4 / 50 = 8 ms.

2.2. PRESSING PRESSURE

If we use the pressing pressure according to [3] can be calculated :

$$q = \beta_{hm}\, V\, \frac{dp_1}{dt} \qquad (3)$$

$$\text{and } q = v\,f \qquad (4)$$

So, it is clear that adjustable pressure valve the force from the hydraulic medium pressure on the valve front plus the force from the speed of the flowing hydraulic medium equals the force from the valve spring plus the force from the accelaration of the valve mass.

$$\beta_1 F + vk\,F = Cx + m\,\frac{d^2x}{dt^2} \qquad (5)$$

When we choose the conditions that we can neglect the force from the acceleration against the force from the valve spring. Then can be expressed

$$\beta_1 F + vkF = Cx \qquad (5.1)$$

We substitute the equations (3), (4) into the equation (5.1) and we get

$$\frac{C}{k}\,\frac{f}{F}\,x = p_1\,\frac{f}{k} + \beta_{hm}\,V\,\frac{dp_1}{dt} \qquad (6)$$

after arrangement we get

$$S_{pl} = \frac{P_1}{X} = \frac{C}{F}\left(1 - \frac{p}{\frac{f}{k\beta_{hm}V} + p}\right) \qquad (7)$$

The original to the transient characteristic

$$P_1 = \frac{C}{F}\left[1 - \exp\left(-\frac{f}{k\beta_{hm}V}\,t\right)\right] \qquad (7.1)$$

Where the time constant is

$$t_o = \frac{k\beta_{hm}V}{f} \qquad (7.2)$$

and for real conditios should be designed

$$t_o = \frac{\Delta p_1 . V . \beta_{hm}}{vf} \qquad (7.3)$$

when $\Delta p1$ = 0,1 MPa, V = 0,02 m3 , βhm = 5,5 .10-6 + 1. MPa-1, f = 0,015 m2, v = 80 ms-1 then t0 = 9 ms
where is :
p – the pressure of melting metal at die cavity filling
pox – the pressure for breaking surface oxide membrane
pg – the pressure of air and gas against the melting metal flow in a die cavity
ν - the melting metal viscosity
v - the melting metal flow speed in the die cavity
δ - the melting metal surface tension
ϑ - the melting metal adhesion to a die material
l - the melting metal flow length
d - the melting metal flow hydraulic diameter
s - the melting metal specific mass
g - the gravity acceleration
t - the time
V – the closed hydraulic medium volume in the pressing pressure
p1 – the pressing pressure
βhm - the compressibility coefficient of the hydraulic medium
q - the hydraulic medium passage through the adjustable pressure valve
f - the hydraulic medium passage area
F – the valve front area
k - the hydraulic resistance coeficient of the valve
C – the spring constant of the valve
m – the moving mass of the valve
Cx – the opening of the valve

2.3. PROCESS CONTROL

At speed control we can derive feedback from the movement of the pressing cylinder, at pressure control.

At a regulator with the transfer Rv(p) [Rpl(p)] we can derive the following transfers of the controlled system. The transfer of manipulated variable for speed

$$F_v = \frac{V}{\frac{1}{\Xi}} = \frac{S_v(p)}{1+R_v(p).S_v(p)} \qquad (8)$$

For pressure

$$F_{pl} = \frac{P_1}{X} = \frac{S_{pl}(p)}{1+R_{pl}(p).S_{pl}(p)} \qquad (8.1)$$

The transfer of failure for speed

$$F_{vpl} = \frac{V}{p^1} = \frac{1}{1+R_v(p).S_v(p)} \qquad (9)$$

for pressure

$$F_{plpl} = \frac{P_1}{p^1} = \frac{1}{1+R_{pl}(p).S_{pl}(p)} \qquad (9.1)$$

Then the transfer of control speed

$$F_{vw} = \frac{V}{W} = \frac{R_v(p).S_{pl}(p)^1}{1+R_v(p).S_v(p)} \qquad (10)$$

for pressure

$$F_{plw} = \frac{\beta_1}{W} = \frac{R_{pl}(p).S_{pl}(p)}{1+R_{pl}(p).S_{pl}(p)} \qquad (10.1)$$

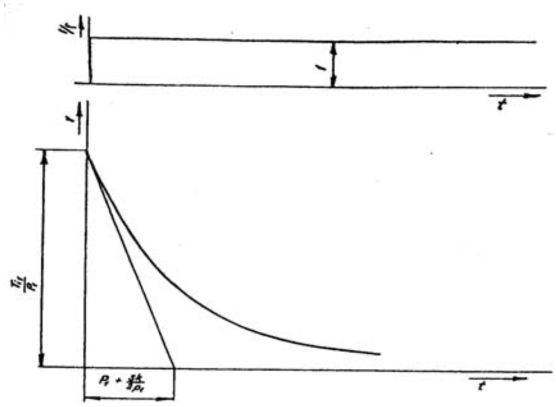

Fig.1 The transient characteristic of manipulated variable at control

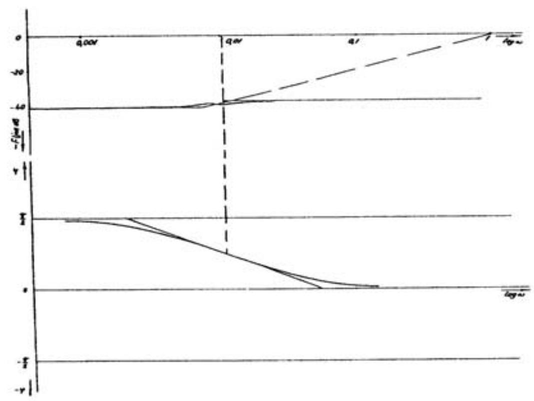

Fig. 2 The amplitude and phase characteristics of manipulated variable at control

Optimally when we choose a regulator PI then it is possible to prove for te transfers of manipulated variable Fv, Fpl that the circuit is aperiodical or damped oscilating. The transient stable characteristic is in figure 2 and the amplitude and phase characteristics in figure 3.

3. CONCLUSION

Research and optimization of the control mechanism and design of basic the equations (1), (1.1) and (1.2) are valid for the flow speed of the melting metal at filling die cavity in pressure die casting and (3), (4), (5), (5.1) and for pressing pressure. By simulating in transparent dies with water it is possible to watch a flow front with typical widening and continuing in opposite direction to the inlet.

Through arrangement of derived differential equations for speed and pressing pressure it is possible to prove that the circuit is stable aperiodical or damped oscilating and to warrant favourable characteristics of manipulated variable, failure and control.

REFERENCES

[1]VALECKÝ, J.: Metal casting under the pressure. Praha, SNTL, 1963,
[2] RAGAN, E.: Viscosity and initial stress in aluminium in period of crystalinity, Metalurgy papers1969, n.12, pp. 864-872
[3] RAGAN, E.: Contribution in theory of similarity pressure die casting, Metalurgy, 1970, n.12, pp 492.
[4] KUBÍK, S., KOTEK, Z., ŠALAMON, M.: Theory of regulation Praha, SNTL 1968.
[5] RAGAN, E.: Metals Pressure die casting. Prešov, 2007, ISBN 80-8073-979-9
[6] MALÍK, J., DŽUPON, M., KOMÁR, J.: Chyby odliatkov liatych do kovovej formy pod tlakom. ACTA Metallurgica Slovaca 11, n.3, p.138-141, ISSN 1335-1532
[7]VASILKO, K., MARCINČIN, J.N., HAVRILA, M.: Výrobné inžinierstvo. TU Košice FVT v Prešove, 2003, 424 s., ISBN 80-7099-995-0