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[1.] VÁCLAV ŠTROBACH

DESIGN OF EXPERIMENTS FOR THE PRESSURE DIE CASTING PROCESS

Abstract:
Due to the car-making industry development, the foundry work, especially pressure casting technology has known an important growth. This technology enables the fabrication of thin-walled castings with a high precision which are based on aluminium alloy.
Such exact and light parts are one of the premises for the car-making industry – parts with a low weight and exact products directly influence the fuel consumption of an automobile, and consequently the users are satisfied.
This article describes one of the ways for the design of experiment in foundry work-design of experiment for the technology of pressure die casting process. Modern methods are used in that, i.e. Ishikawa diagram and Central Composion then, the process is applied to real conditions which are involved in the process and affect it considerably. Afterwards, the experiment is tested.

Keywords:
experiment, Ishikawa diagram, casting parameter, pressure dies casting

INTRODUCTION

Recently, due to the car-making industry development, the foundry work, especially pressure casting technology has known an important growth. This technology enables the fabrication of thin-walled castings with a high precision which are based on aluminium alloy.
Such exact and light parts are one of the premises for the car-making industry – parts with a low weight and exact products directly influence the fuel consumption of an automobile, and consequently the users are satisfied. Pressure die casting methods in %, see fig. 1. [1]

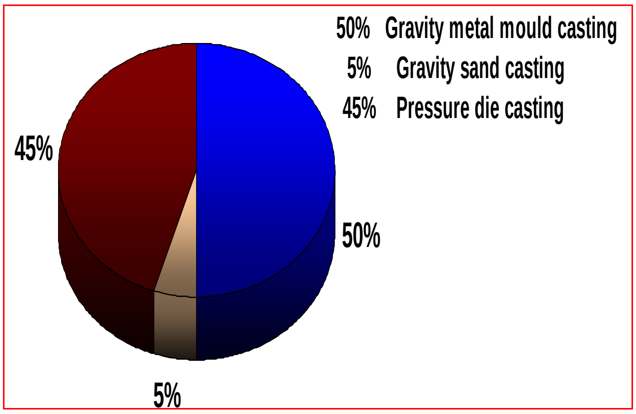

Fig. 1 Pressure die casting technology methods in %

FACTORS INVOLVED IN THE PRESSURE DIE CASTING PROCESS

A detailed analysis of each factor entering in the fabrication of a high pressure casting is necessary to carry out, since each factor is susceptible to influence the ready casting in a negative way. The pressure die casting technology produces the thin-walled castings having a high dimensional and geometric precision. So, we try to manage the whole die casting process – to control all factors involved in the process in order to prevent waste castings. The casting which doesn't fulfil the dimensional, geometric, structural and superficial requests is considered as a waste. The factors involved in the process are described by Ischikawa diagram – causes and consequences, see fig. 2. The diagram presents in detail the factors influencing directly the final quality of a high pressure casting.

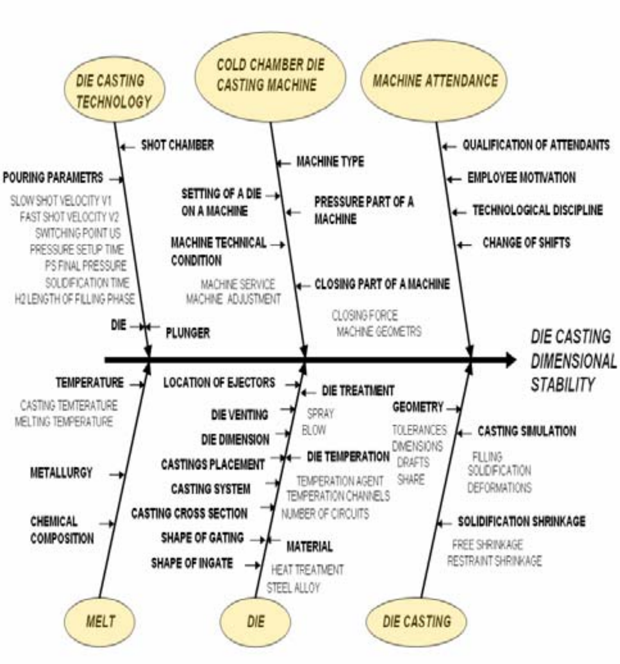

Fig. 2 Ischikawa diagram

EXPERIMENT - PREPARATION

The experiment is aimed to find out how, in which degree the casting dimensional stability depends on the pouring parameters. Based on experiences, among many parameters, the following parameters have been chosen:

- *Liquid alloy temperature;*
- *Working temperature of the mould;*
- *Filling velocity 2. phase;*
- *Solidification time.*

The method of the central composition is followed (one of the DOE methods). It permits to define the minimal number of the experiments including all possible combinations of the requested parameters.

Before carrying out this method the limits within the parameters will move, have to be defined. The parameters ranges are established according to the worksite, in part, and according to the quality of the castings. The parameters values are written in the table 1.

Tab.1 Pouring parameters ranges

Pouring parameter	Identification / Unit	Level				
		-2	-1	0	1	2
Alloy temperature	T_L [°C]	660	675	690	705	720
Mould temperature	T_F [°C]	100	125	150	175	200
Filling velocity	∇_2 [m.s-1]	2,1	2,35	2,6	2,85	3,1
Soldification time	t_{t}. [s]	5	6	7	8	9

Tab. 2 Groups of pouring parameters

Measurment no.	T_l [°C]	T_f [°C]	∇_2 [m.s^{-1}]	t_t [s]
1	675	125	2,35	6
2	705	125	2,35	6
3	675	175	2,35	6
4	705	175	2,35	6
5	675	125	2,85	6
6	705	125	2,85	6
7	675	175	2,85	6
8	705	175	2,85	6
9	675	125	2,35	8
10	705	125	2,35	8
11	675	175	2,35	8
12	705	175	2,35	8
13	675	125	2,85	8
14	705	125	2,85	8
15	675	175	2,85	8
16	705	175	2,85	8
17	660	150	2,6	7
18	720	150	2,6	7
19	690	100	2,6	7
20	690	200	2,6	7
21	690	150	2,1	7
22	690	150	3,1	7
23	690	150	2,6	5
24	690	150	2,6	9
25	690	150	2,6	7
26	690	150	2,6	7
27	690	150	2,6	7
28	690	150	2,6	7
29	690	150	2,6	7
30	690	150	2,6	7

During the carrying out the method, the level from -2 to 2 including 0 is assigned to each parameter. After have introduced in a 5level, 4factor matrix containing combinations of singular levels, the values of the parameters are inserted behind the levels. In this way, the groups of pouring parameters are defined, it means 30 groups. Such an experiment includes 7 groups of the identical pouring parameters, see tab. 2.

ALLOY

The alloy EN 1706 AlSi12Cu1(Fe), identification number EN AC 47100 is used for the casting fabrication The chemical composition of the alloy is in the table 3. This chemical composition was identified by the spectral analysis.
The charge (new and recuperative material, proportion 60/40) was melted in the gas-fired crucible Morgan filled with a graphite crucible whose volume is 800 kg. While melted, the liquid had been enriched with the refining salt COVERAL GR 2410. Have been melted and warmed up until 780°C, the alloy was transferred into a transport crucible and degasified by nitrogen in the FDU – FOSECO. The degassing took 3 min, the rate of gas flow being 20 l.min-1. Degasified, the alloy was removed into a holding furnace STRIKO WESTOFEN W 650 SL ProDosand. From this one the doses of the requested alloy quantity passed automatically into the pouring chamber of a pressure die casting machine. The temperature of the alloy in the holding furnace was measured by a built-in thermocouple NiCr-Ni.

Tab. 3 Chemical composition of the alloy, spectral analysis

Elements contained in the alloy AlSi12Cu1(Fe) (%)					
Al	Si	Fe	Cu	Mn	Mg
85,18	11,58	0,759	1,13	0,238	0,274
Cr	Ni	Zn	Pb	Ti	
0,039	0,066	0,537	0,068	0,115	

FINDINGS

All pressure castings are casted at a working site where a pressure casting machine with a cold horizontal chamber CLH 400.03 are. The working site is connected to the control system ELAP RSE 10.52. The pressure casting mould is put only once. Its temperature is hold by a thermoadjusting device Thermobiehl.

There is a necessary condition for the experiment – the setting up of the pouring parameters. The parameters are set up following the table 2.
When the parameter setting up is finished, 5 castings are always done in order to stabilize the parameters and then, 10 castings necessary for the experiment are effectuated. During the melting of each casting the real values of the parameters are read and written. When the casting is out of the mould, there is no cutting at the press to avoid casting strains and consequently distorted results. When all the castings are ready and cold, the preparatory operations for the measurements are done. Flashes are carefully taken out and the ingate is cut by a frame saw. Then the castings are submitted to a dimensional analysis by the coordinate measuring machine. The results are evaluated with the objective to determinate the optimal casting parameters in the die casting process.

CONCLUSION

During the preparatory phase of the experiment the results are practically verified. Pouring parameters responding to the parameters 22, ie melt temperature 690°C, mould temperature 150°C, filling velocity of mould cavity 3,1 m.s-1 and solidification time 7s. When these parameters are set up at the pressure die casting machine, there is a dimensional stability of the castings. They have requested dimensions. This is also able to be used for an other type and quantity of the casting parameters. We can say that using modern statistic methods for the preparation of the experiment, a saving time in the production and a reduction of the direct costs spent on an accidental search of the optimal parameters, so both these aspects are reached. More specialists must participate in Ishikawa diagram setting up because the view of the problem is then objective.

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AUTHOR & AFFILIATION

[1.] *VÁCLAV ŠTROBACH*

[1.] *TECHNICKÁ UNIVERZITA V LIBERCI,*
FAKULTA STROJNÍ, LIBEREC, CZECH REPUBLIC

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