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Homogeneity of Die Casting and Returning Material

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Abstract

Homogeneity of die castings is influenced by wide range of technological parameters as piston velocity in filling chamber of die casting machine, filling time of mould cavity, temperature of cast alloy, temperature of the mould, temperature of filling chamber, surface pressure on alloy during mould filling, final pressure and others. Based on stated parameters it is clear, that main parameters of die casting are filling time of die mould cavity and velocity of the melt in the ingates. Filling time must ensure the complete filling of the mould cavity before solidification process can negatively influence it.

Among technological parameters also belong the returning material, which ratio in charge must be constrained according to requirement on final homogeneity of die castings. With the ratio of returning material influenced are the mechanical properties of castings, inner homogeneity and chemical composition.

Keywords: Theory of Crystallization, Innovative Foundry Technologies And Materials, Die Casting, Die Casting Machine, Alloy, Mould, Casting, Returning Material

1. Introduction

Technology of die casting belongs to the methods of exact casting and is nearly ideal effort of change of basic material to final product. By die casting, the metal is compressed with high velocity into the cavity of die casting mould. The difficultness of the question of filling of mould cavity is, that factors as construction of the casting and heat balance of the die in reality define the real flow of the melt. On quality of the die castings have influence technological factors, to which belong:

- velocity of compression
- surface pressure on melt
- filling time of die
- temperature of cast alloy, temperature of the die

These factors influence each other and it is needed to know the relation of the whole casting process from the beginning of the die cavity filling to solidification of the casting in the mould. One

of the technological factors influencing the quality of the castings is the returning material.

2. Returning material

Casting production with die casting technology brings out its economy sufficient amount of returning material, which is needed for further reappraisal in production to carefully sort and stock.

Returning material is mainly gating systems, feeders and other foundry additions. During production and working these are spills, sawdust, clippings, shearings, wrong castings. By the cold chamber machines these are also residues of cold chamber.

Amount, resp. ratio of returning material in die casting production depends on construction and size of produced casting.

Massive castings need less feeding metal from feeders than plate castings with same modulus.

It is given, that for gatings and other foundry additions is needed from the weight of raw casting:

for massive castings	.....	10 - 25%
for middle-weight castings	.....	25 - 100%
for small castings	.....	100 - 300%.

This means that according to the casting size can be presented the amount of returning material from 20% for big castings to 75% for small castings. When taking into account the alloy quality it is useful to cast whole series into one mould for small castings. We can not forget, by the evaluation of the returning material amount for the charge, material losses in circulation of material through foundry and finishing mill. These losses rise from burnout by melting and holding of molten metal, splashing during pouring and also wastes of small sawdusts during cleaning of the castings. They are higher when the amount of returning material is higher. It rises also with the amount of wrong castings by cleaning, splashing of the metal and remelting the wrong castings.

They are given in this range:

Zn alloys	.....	4,5 - 7%
Al alloys	.....	10 - 15%
Mg alloys	.....	30 - 40%
Cu alloys	.....	12 - 18%

They refer to the weight of clean casting. By very small castings they can be even higher.

To the returning material belong weight-important residues from cold chamber. To returning material always belong wrong castings.

When using cold chamber machines is the amount of returning material from total average weight of molten metal needed for one casting always higher than it is with hot chamber machines. It represents up to 65% of molten metal weight, it means 2 times the weight of raw casting. The amount of returning material for hot chamber machines is 45-50% of the molten metal weight.

For preservation of properties is very important to sort returning material. It must be distinguished whether the returning material is clean or not clean. As clean returning material should be considered wrong castings and in some cases also gating systems. Polluted returning material creates by cold chamber machines mainly the residues from filling chambers, which are oiled, splashed alloy which is taken from the floor and wrong castings that are coated with oil. It depends on the alloy, what to do with these kinds of returning material. Polluted returning material of all alloys can never be charged into holding furnace for direct production of the castings, it must be remelted and emphatically and effectively refined.

3. Utilization of castings with returning materials

The ratio of returning material in charge is limited according to requirements on final quality of the die castings. With the ratio

of returning material are influenced mechanical properties of the castings, inner homogeneity and chemical composition. From consequent knowledge is evaluated the usage of aluminium alloys for particular industry branches - electrotechnical, automotive or aerial industry.

Based on mechanical properties can be judged the utilization of returning material for wide sort of die castings. Because of with increasing amount of returning material being charged comes to negative influence of mechanical properties of the castings, it can be stated, that alloys with increasing amount of returning material would be used for casting production, where are not high requirements for mechanical properties. Their utilization is also evaluated based on inner homogeneity, which has the influence on loading from the infringement of material point of view.

Alloys with low ratio of returning material have good qualitative properties and are sufficient for casting production with high requirements on mechanical properties, e.g. engine holder, crank-shaft etc. Alloys with lower quality are useful for casting production with low value of mechanical properties, e.g. alternator casing, different cramps, boxes etc.

4. Methodology of experiment

Utilization of returning material is dependant from its influence on properties of produced castings. With the ratio of charged returning material is influenced the cleanness of the melt, chemical composition, metallurgical processes and changes of final structure in the castings and mechanical properties. This experimental approval was done on castings with different ratio of basic and returning material, see Tab. 1.

Table 1.

Amounts of basic and returning material in individual samples		
Sample	Amount of basic material [%]	Amount of returning material [%]
A	100	0
B	70	30
C	50	50
D	30	70
E	0	100

The experiment was executed on new series of produced castings, engine holders with the name Halter-B, Fig. 1

The original material for pouring of sample castings was alloy AlSi9Cu, which chemical composition according to norm is shown in Tab. 2

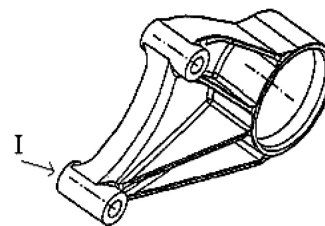


Fig. 1. Die casting Halter-B

Table 2.

Chemical composition of alloy according to STN EN 1706 Amount of Al > 84 %

Chem. element	Si	Fe	Mn	Mg	Cu
min.	8.00	0.60	-	0.05	2.00
max.	11.00	1.30	0.55	0.55	4.00

Pouring of sample castings was executed on die casting machine with cold horizontal filling chamber, type CLOO 400/36-B2 with these technological parameters:

- diameter of filling chamber 60 mm
- temperature of alloy 660°C
- basic pressure 30 MPa
- piston velocity in filling chamber 2,5 m.s⁻¹
- height of metal residue in chamber 25 mm
- mould temperature 220°C.

Analysis of chemical composition of individual meltings was executed on spectrometer SPECTROCAST. Inner homogeneity of analysed castings was realized by non-destructive method on device RTG VX 1000D. Measurement of mechanical properties was realized by measuring of permanent deformation after pressure loading on universal device TIRAtest 2300 according to norms GMNE 06 007 and GME 60 156 and hardness measurement according to Rockwell.

5. Measured values

Chemical composition of individual melts according to the ratio of returning and new material is shown in tab. 3

Table 3.

Chemical composition of alloys for individual meltings

Sample	Al	Si	Fe	Mn	Mg	Cu
A (100/0)	84.11	11.12	0.97	0.43	0.31	2.57
B (70/30)	84.06	10.90	0.98	0.58	0.29	2.26
C (50/50)	83.57	10.81	1.04	0.48	0.51	2.41
D (30/70)	83.42	10.62	1.13	0.36	0.34	2.48
E (0/100)	83.33	10.56	1.19	0.43	0.30	2.41

From chemical composition of individual melts can be seen, that in process of melting and holding of molten metal comes to increasing of the Al and Si amount (Fig. 2-3), which means that there occur losses by burnout and also comes to increase of the amount of Fe (Fig. 4).

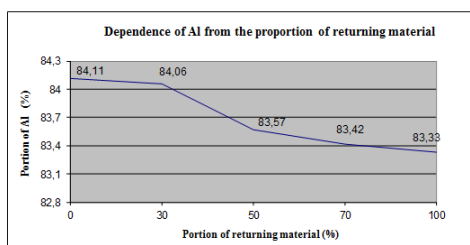


Fig. 2. Change of the Al amount with the ratio of returning material

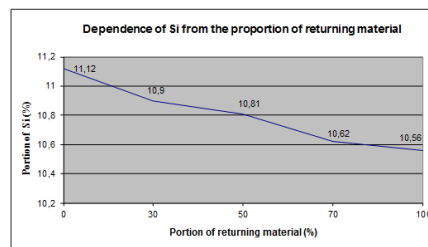


Fig. 3. Change of the Si amount with the ratio of returning material

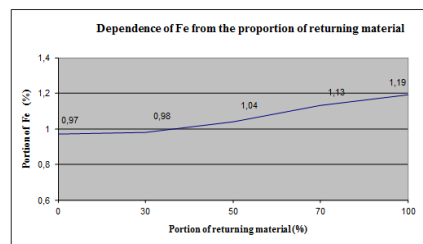


Fig. 4. Change of the Fe amount with the ratio of returning material

Mechanical properties of tested samples were executed with the test of permanent deformation after pressure loading $F_a = 87,6$ kN and by half load $F_m = 43,8$ kN was created permanent deformation according to loading diagram, Fig. 5 and hardness measurement.

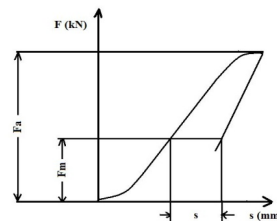


Fig. 5. Loading diagram for one-axis pressure loading

Measurements were executed on casting in the place of clamping opening I, Fig. 1 and final values are stated in Tab. 4.

Table 4.

Measured values of permanent deformation and hardness

Sample (čistý/returning material)	Permanent deformation (mm)	Hardness HRC	
		top edge	bottom edge
A (100/0)	0.234	57.0	57.5
B (70/30)	0.252	58.0	58.0
C (50/50)	0.268	57.5	58.0
D (30/70)	0.284	59.0	58.5
E (0/100)	0.308	59.0	59.0

Increasing of the ratio of returning material negatively influences mechanical properties from the point of view of increasing value of permanent deformation, Fig. 6. Important

difference between measured values of hardness in this experiment was not documented.

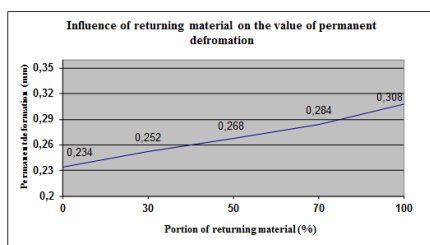


Fig. 6. Influence of returning material on the value of permanent deformation

The evaluation of inner homogeneity of the casting was realized on taken samples from analysed castings in the dividing plane of clamping opening by evaluation of RTG pictures and evaluation of the structure. Structures from two melts are shown in Fig. 7 and RTG pictures of analysed castings are shown in Fig. 8.

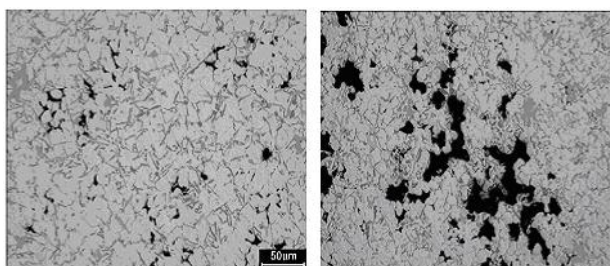


Fig. 7. Structure from first and fifth melt

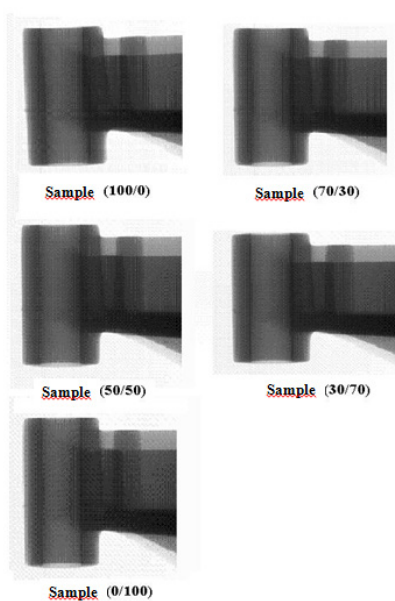


Fig. 8. RTG pictures of clamping opening of each tested castings

6. Conclusions

The ratio of returning material in die castings highly influences their chemical composition. With increasing of the returning material ratio comes to decreasing of important elements as Al and Si with increasing of Fe, which can cause negative influence on foundry and mechanical properties.

Measured values of permanent deformation confirm the negative influence of returning material ratio on mechanical properties of die castings. The highest value of permanent deformation 0.308 mm was measured when using 100% of returning material. The important difference among measured values of hardness in this experiment was not documented.

During evaluation of microstructure of the samples is evident the influence of returning material on final structure, which in Fig. 7 documents the amount of returning material.

By RTG analysis of sample castings was not shown any influence of returning material on inner homogeneity of the casting, although negative influence of returning material was documented also on structures, the higher the amount of returning material, the higher porosity of the casting.

Measured values agreed the negative influence of returning material on casting quality, which is caused by its content in the melt.

Returning material takes into melting process and preparation of the melt a lot of unwanted aspects, but in the case of decreasing the costs with buying of pure alloy according to STN, creates unseparable part of the process of casting production.

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