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TECHNOLOGICAL PARAMETERS OF DIE CASTING AND QUALITY OF CASTING FROM EN AC46500 ALLOY

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Die casting represents the highest technological level of metal mold casting. This technology enables production of almost all final products without necessity of further processing. The important aspect of efficiency and production is a proper casting parameters setting. In the submitted paper following die casting parameters are analyzed: plunger pressing speed and pressure. The studied parameters most significantly affect a qualitative of castings from EN AC46500 alloy and they influence the most a gained porosity level as well as basic mechanical properties represented by permanent deformation s.

Key words: die casting parameters, pressure, permanent deformation, microstructure, quality of cast

INTRODUCTION

The issue of technological factors of die casting, which plays an indispensable role in the production of lower weight category casts, mainly from aluminium, magnesium and zinc alloys, is nowadays a subject of numerous studies on a global scale [1].The technology of die casting into a metal molds is currently extensively used owing to a wide range of technological and economic advantages such as: high size accuracy of the casts, smoothness of the surface with minimal extra working, possibility to manufacture casts of complex shapes with pre-cast openings, fine-grained texture conditioned by high accumulative ability of the mold and by specific pressure acting on the metal in the process of the casting cycle, lower weight of the casts, higher usability of metal, lower labour - intensiveness of finishing operations and so on. [2, 3]

The following technological parameters affect the quality of die castings [1, 4]:

- pressing velocity during a casting cycle,
- time of filling a die cavity,
- temperature of a cast alloy,
- temperature of a filling chamber,
- temperature of a pressure die.

The mentioned factors are mutually influenced [5]. This refers to a complex of mutual relations between an alloy character, time of a die filling and the effectiveness of a die-casting machine, i.e. the knowledge of the principles of a complete die casting process from the beginning of a die cavity filling to a solidification of a casting in a die. [6, 7]

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EXPERIMENTAL METHODICS AND APLLIED MATERIALS

The analyzed testing castings of the same type denoted as Halter B, Figure 1, were cast in two series, 20 pieces each. The series A was cast with a pressure die casting machine with a clamping force of 400 t and the series B was cast with a pressure die-casting machine with a clamping force of 250 t. The technological parameters of die-casting are shown in Table 1 and a chemical composition of the cast alloy is in Table 2.

By a random sampling, 96 hours after the completion of the die casting process, unfinished castings of the series A and B, 10 pieces each, were put under a

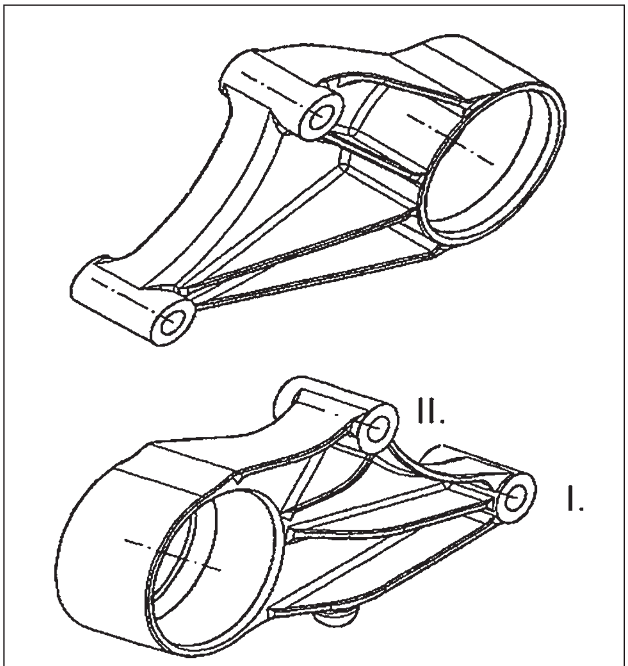


Figure 1 The casting HALTER B

Table 1 **Technological parameters of a die casting**

PCM 1 – clamping force 400 t
Die-casting parameters: - pressure: 34 MPa - plunger pressing speed: 2,5 $m.s^{-1}$ - alloy temperature: 644 °C
PCM 2 – clamping force 250 t
Die-casting parameters: - pressure: 35 MPa - plunger pressing speed: 2 $m.s^{-1}$ - alloy temperature: 645 °C

Table 2 **Chemical composition of experimental alloy EN AC 46500 / wt. %**

Al	Si	Fe	Cu	Mn	Mg
85,04	9,32	0,96	3,0	0,29	0,32
Cr	Ni	Zn	Pb	Sn	Ti
0,02	0,09	0,88	0,02	0,03	0,03

static compression test carried out with a testing device TIRAtest 2300.

It was supposed that the most venturesome fields of possible defects occurrence with a pressure casting of the analyzed castings would be the orifices I and II, Figure 1, as when charging the die, this part of the casting was charged as the last one. The orifices serve to fix a part with a screw, therefore, according to the standard, conditions of their testing are determined.

The measuring of a permanent deformation after a pressure load was carried out based on the standards GME 06 007 and GME 60 156. [8, 9] The first standard is related to the experimental procedure and the second one refers to the evaluation method of a permanent deformation test measured at the orifices I and II (Figure 1).

The pressure load F_a was 87,6 kN and with the half load F_m = 43,8 kN a permanent deformation occurred according to a load diagram, Figure 2.

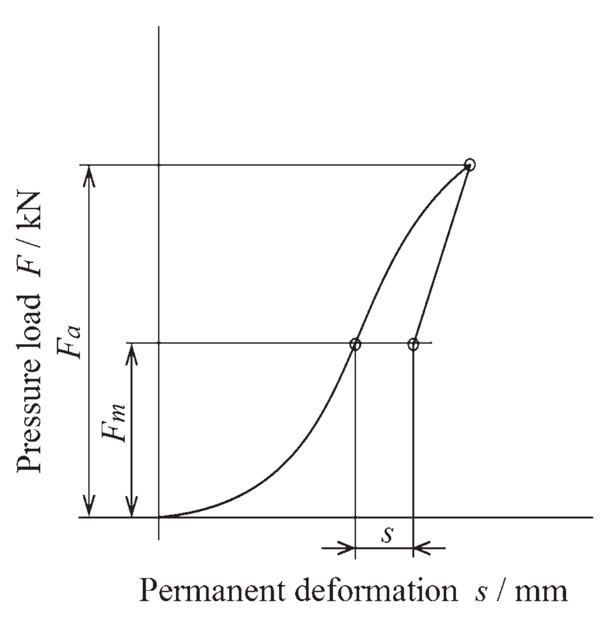


Figure 2 A load diagram for uniaxial tensile strength

Based on the values prescribed by the standard a permanent deformation with F_a load (a load of 50 %), has the value 0,230 mm, which is 0,5 % of a compressed length *1* = 46 mm of the orifice with the neighbourhood temperature of 22,5 °C and a load speed 2 mm/min. The diameter of a push broach is d_1 = 26 mm and that of the orifice is d_2 = 13 mm.

The measured values of a compression test are given in Table 3.

Table 3 **Values of a permanent deformation of the orifices**

PCM.1 – series A		
Notation of a casting	Orifice I. *s* /mm	Orifice II. *s* /mm
A.1	0,228	0,190
A.2	0,230	0,205
A.3	0,240	0,200
A.4	0,233	0,204
A.5	0,232	0,195
A.6	0,220	0,200
A.7	0,228	0,203
A.8	0,230	0,205
A.9	0,245	0,222
A.10	0,227	0,202
Average	0,231	0,202
Difference	0,029	
PCM.2 – series B		
Notation of a casting	Orifice I. *s* /mm	Orifice II. *s* /mm
B.1	0,178	0,180
B.2	0,176	0,170
B.3	0,183	0,176
B.4	0,180	0,173
B.5	0,194	0,178
B.6	0,185	0,178
B.7	0,175	0,160
B.8	0,188	0,172
B.9	0,178	0,170
B.10	0,182	0,182
Average	0,181	0,173
Difference	0,008	

In order to evaluate the microstructure, those castings of both series were selected which had the highest

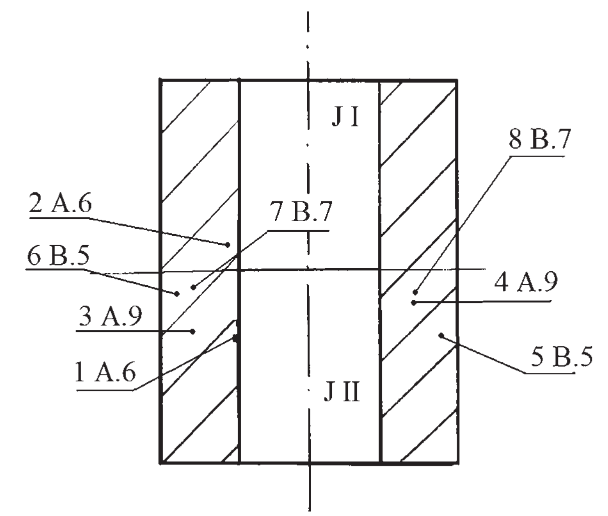
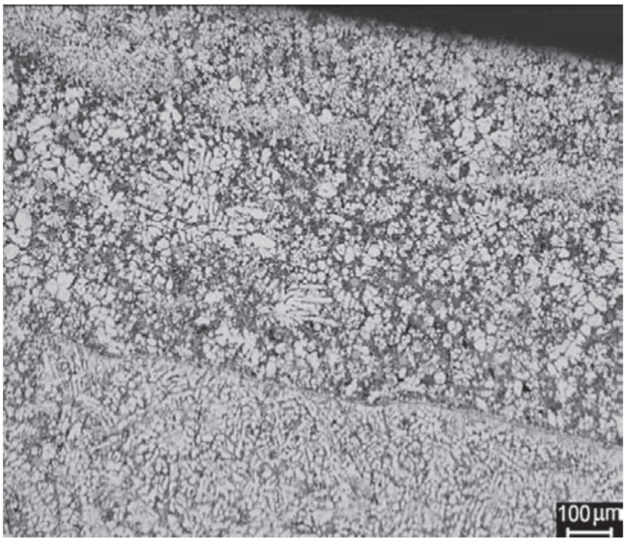
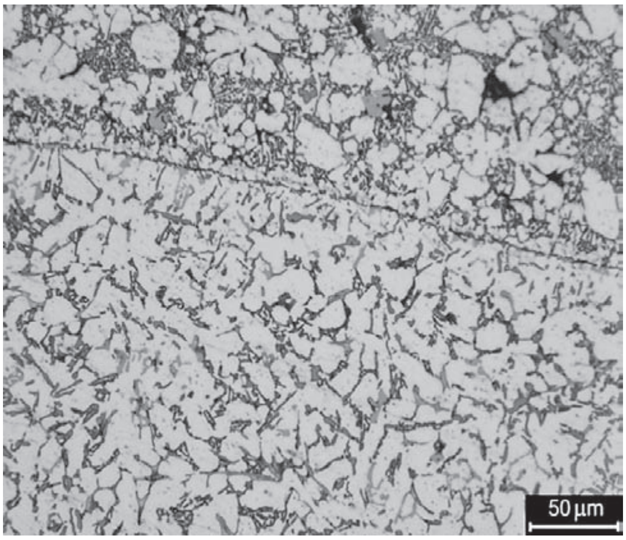


Figure 3 The orifice I. section of the casting to evaluate the microstructure with denoted positions

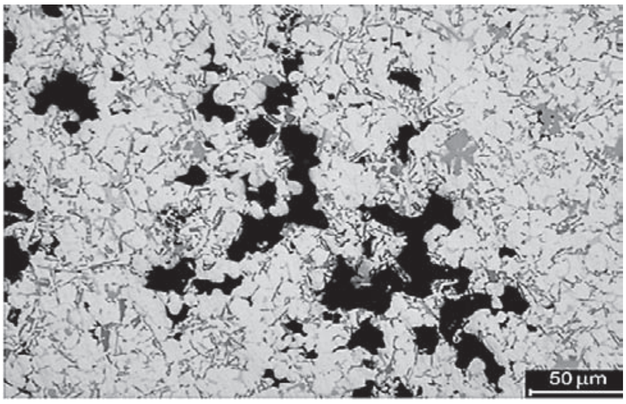


a) position - 1

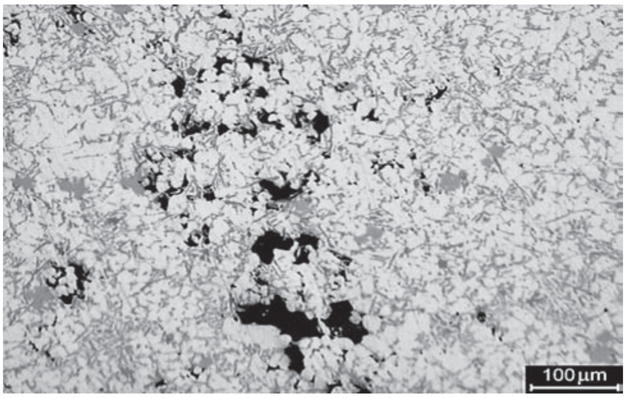


b) position - 2

Figure 4 Microstructures of the samples A.6



a) position - 3

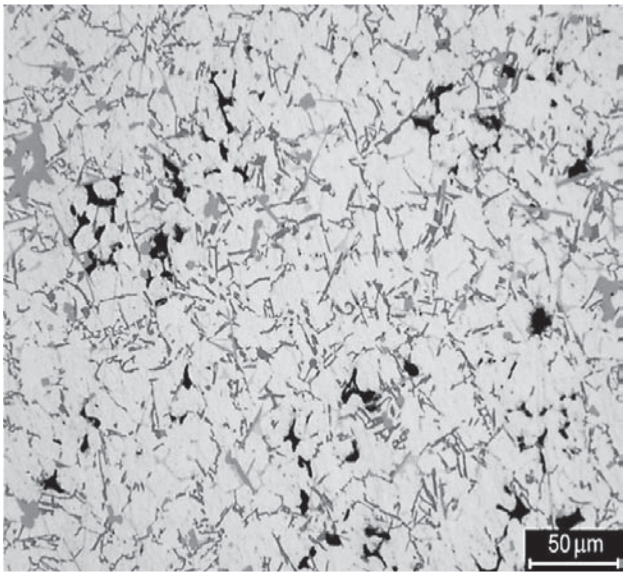


b) position - 4

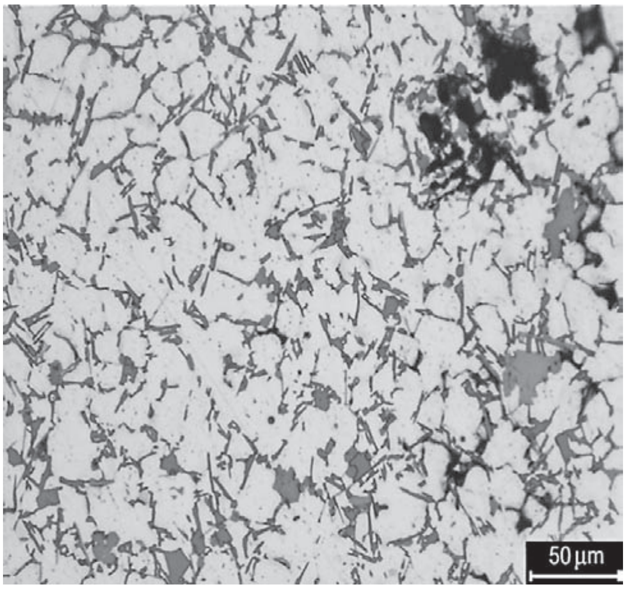
Figure 5 Microstructures of the samples A.9

and the lowest measured values of a permanent deformation with the orifice I (A.6, A.9, B.5, B.7). The microscopes Neophot 32 and Olympus were used to analyze the section of the casting microstructure close to the die surface, in layers under the surface near the core and in the area of a parting line as well as aside it according to the positions presented in Figure 3.

In Figures 4 - 6, there are analyzed selected microstructures in individual positions according to Figure 3.



a) position - 5



b) position - 6

Figure 6 Microstructures of the samples B.5

ACHIEVED RESULTS AND THEIR ANALYSIS

The measured values of a permanent deformation presented in Table 3 show the differences between a standardized maximum value *s* = 0,230 mm and the real values as well as the differences between the series of the castings cast in pressure die-casting machines PCM 1 and PCM 2. With the castings of the series A, the measured values of a permanent deformation approached the maximum value.

With four cases this value was exceeded and the castings did not satisfy a static compression test. It is proved by higher differences in the measured values between the orifices I and II, which is demonstrated by the difference in values average 0,029 mm of the orifices. With the series B, the measured values did not exceed the maximum standard value. Comparing the measured values of the orifices I and II of the analyzed castings, there were evident only minimum differences which was proved by the difference in values average 0,008 mm of the orifices.

Based on the measured values of a permanent deformation of the orifices it follows that the die filling with the castings of the series B was carried out uniformly and the technological parameters of the casting operation were satisfying. The deciding parameter was a plunger speed inside a filling chamber which determines the regime of a die cavity filling in its individual parts. It was supposed that the different values of a permanent deformation were caused by air bubbles closed in the central part of the casting orifices. The orifices are formed by two metal cores, which, after a die is locked, touch by faces in a parting line. A slot mouth in a die cavity is in the parting line denoted by an arrow in Figure 1. After pressing in a metal in a filling chamber, the melt from the slot fills a die cavity in a high speed. A molten metal flows around the metal cores and by a turbulent flow removes the air from a die cavity and closes it inside of the casting, in its central part, in the form of air bubbles. The values of a permanent deformation depend on the size of the air bubbles and their distribution. They appeared with the series A with the speed 2,5 $m.s^{-1}$. With the series B, with the speed 2 $m.s.^{-1}$, air bubbles were supposed to be of smaller size and in a smaller number. The microstructures of samples taken from the orifice I of the series A and B proved that the main cause of a permanent deformation were air bubbles, see Figure 3.

The sample microstructure in Figure 4 illustrates a laminar filling. After the initial skin is created on a metal core due to a rapid cooling, it remains on a core and another flow of a melt of a different microstructure is injected between the core and a more distant part. The air in the peripheral part and in a minimum distance from the core is not closed into the casting. In Figure 5, there are samples microstructures of the analyzed casting of the series A, position 3, where the highest value of a permanent deformation caused by air bubbles was measured. By a turbulent filling, they are closed in a central part of the orifice. In Figure 6 is the microstructure of the analyzed casting of the series B with the lowest (B5) value of a permanent deformation.

Different values given in Table 3, correspond with the microstructures in which the air bubbles in the casting body are smaller in size and number.

CONCLUSION

The measured values of a permanent deformation of the orifices of the analyzed castings from ENAC 46500 Alloy as well as the values of the samples microstructures proved that regarding the resulting quality of the casting, the most important parameter of the metal die-casting is the speed of a die cavity filling which determines the regime of a die cavity filling. It depends on the speed of a plunger inside the filling chamber, the size and the design of a slot mouth into a die cavity as well as a die venting.

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Note: The responsible for English language is PhDr. Ivana Dvoriak Matiskova, Prešov, Slovakia