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The Influence of the Proportion of Charge from Waste Materials on the Quality of High Pressure Castings

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Abstract

Nowadays, the most popular production method for manufacturing high quality casts of aluminium alloys is the hot and cold chamber die casting. Die casts made of hypereutectoid silumin Silafont 36 AlSi9Mg are used for construction elements in the automotive industry. The influence of the metal input and circulating scrap proportion on porosity and mechanical properties of the cast has been examined and the results have been shown in this article. A little porosity in samples has not influenced the details strength and the addition of the circulating scrap has contributed to the growth of the maximum tensile force. Introducing 80% of the circulating scrap has caused great porosity which led to reduce the strength of the detail. The proportion of 40% of the metal input and 60% of the circulating scrap is a configuration safe for the details quality in terms of porosity and mechanical strength.

Keywords: Die casting, Al-Si alloys, Circulation scrap, Environment protection, Castings defects

1. Introduction

The process of manufacturing high quality casts uses many casting methods [1-5]. Die casting is a popular production method applied to make details of the aluminium alloys [6,7]. Al-Si alloys are used to produce casts of details in the automotive industry due to their small weigh, high strength to mass relation, good mechanical properties and resistance to corrosion [8,9,10]. Die casting is the most economical and efficient process of producing details of Al-Si alloys. The production procedure, due to economic and quality reasons, should be characterised by appropriate preparation of an alloy for the casting [7, 11-13]. Details made by die casting with the wrong estimation of pouring parameters and inappropriate preparation of the alloy have numerous casting defects (gas porosity, shrinkage porosity, oxide inclusion etc.). These defects contribute to the appearance of scrap. This scrap is reused in the production process. In the article the results of examining the influence of the quantity of the metal input and the circulating scrap on the detail quality have been demonstrated. Due to the protection of environment it is crucial to use the scrap in high quality casts of various metal alloys production to the greatest extent possible [12,13].

2. Experimental Work

The die casting process has been done for the chemical composition of silumin has been shown in the table nr 1.

Table 1.
The chemical composition of the Silafont 36 AlSi9Mg alloy

The chemical composition of the alloy, %					
Si	**Fe**	**Cu**	**Mn**	**Mg**	**Cr**
9.5÷11.5	0.15	0.03	0.5÷0.8	0.1÷0.5	-
Ni	**Zn**	**Pb**	**Sn**	**Ti**	***Al***
-	0,1	-	-	0,15	*rest*

For the research various proportions of the circulating scrap have been used. They are shown in the table nr 2.

Table 2.
The metal input and circulating scrap proportion

The sample No.	The metal input quantity, %	The circulating scrap quantity, %
1.	100	0
2.	80	20
3.	60	40
4.	50	50
5.	40	60
6.	20	80

An alloy in pigs, joined with the circulating scrap, was melted in a double-chamber shaft furnace heated electrically in a temperature of 700^0C. After the melting process, the degree of gas porosity in the Silafont36 alloy was investigated on the ALSPplus device. The alloy, after the refining process, was poured from the holding chamber to the transport ladle. After the refining, the cleaned metal was poured to the holding furnace in the casting machine (alloy temp. 700^0C).The research has been performed on the FRECH DAK350-40 RC cold-chamber die casting machine shown in the Fig. 1. In the process of die casting unchanged parameters for all metal input and circulating scrap proportions have been applied (Table 3). For each metal input and circulating scrap proportion 3 die casts have been made.

a) b)

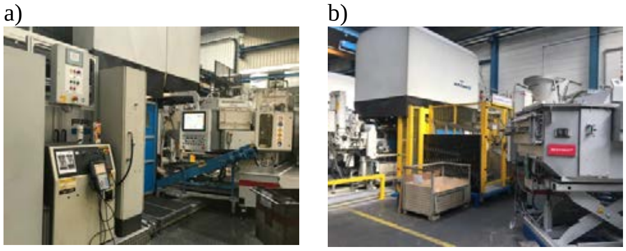

Fig. 1. FRECH Cold-chamber die casting machine: a) view from the front, b) view from the back

Table 3.
The process of die casting parameters

Parameter's name	Parameters set values
Piston displacement, I injection phase, mm	250
Piston displacement, II injection phase, mm	270
Piston velocity, I injection phase, m/s	0.30
Piston velocity, II injection phase, m/s	3.9
Compressing, III injection phase, bar	1050

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a) b) c) d) e) f)

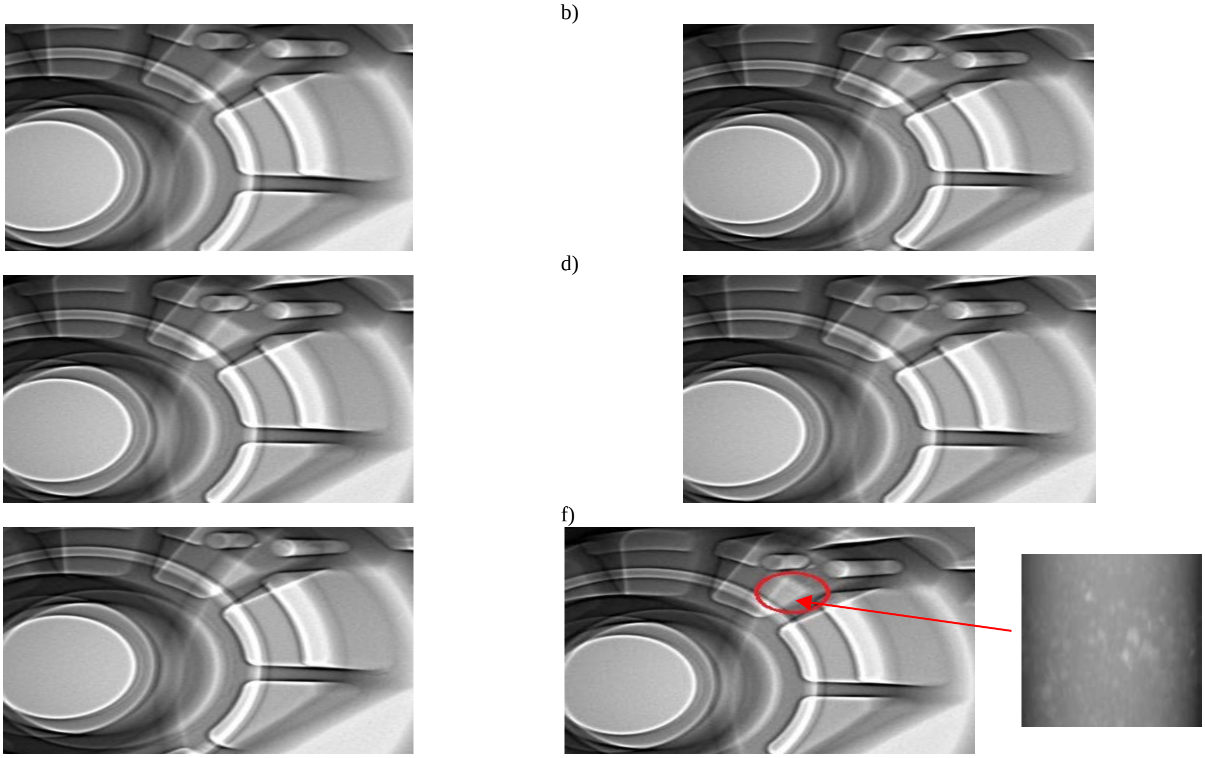

Fig. 2. Exemplary results of the X-ray inspections for the details of various circulating scrap proportions: a) sample No. 1, b) sample No. 2, c) sample No. 3, d) sample No. 4, e) sample No. 5, f) sample No. 6

The influence of particular metal input and circulating scrap proportions on the existence of porosity in a detail has been examined with the use of the YXLON Y.MU2000-D Wheel X-ray inspection system. The results will allow to assess the quality of the cast in respect of porosity.

Below, in the table 4 the results of the X-ray inspection for various metal input and circulating scrap proportions have been presented.

Table 4.
The result of the X-ray inspection for various metal input and circulating scrap proportions

Test No.	Sample No.	The X-ray inspection result
1	1.1	x
	1.2	x
	1.3	x
2	2.1	x
	2.2	x
	2.3	x
3	3.1	x
	3.2	x
	3.3	x
4	4.1	x
	4.2	x
	4.3	xx
5	5.1	x
	5.2	xx
	5.3	x
6	6.1	xx
	6.2	xxx
	6.3	xxx

* x - no porosity, xx - little porosity, xxx - porosity

Below, the results of the strength tests for manufactured details have been shown. In the Fig. 3 an exemplary result of the test and the manufactured sample after the test have been presented.

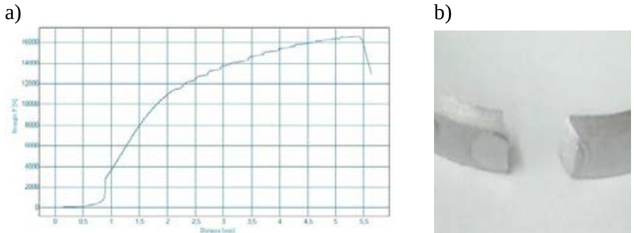

Fig. 3. The result of the strength test of the detail: a) stress-strain curve of a sample, b) picture of a sample - the fracture

In order to extend the quality assessment of the die cast, the strength tests have been planned, to estimate the maximum tensile force (Fmax). The research has been done on the universal testing machine.

Below, in Fig. 2, chosen results of X-ray inspections for the detail made with the use of various metal input and circulating scrap proportions have been presented (Table 2).

Below, in the table 5 the results of the strength tests for the details made in the process of die casting with the use of various metal input and circulating scrap proportions have been presented.

Table 5.
The result of the strength tests with various circulating scrap proportions

Sample No.	Maximum tensile force F_{max}, N	Elongation ΔL, mm	Tensile strength Rm, MPa
1	16621	5,3	519,41
2	16669	5,35	520,91
3	16780	5,6	524,37
4	16869	5,7	527,16
5	17189	6,1	537,16
6	14986	3,7	468,31

Below, in the diagram (Fig. 4), the results of the strength tests for various circulating scrap proportions have been summarised for better illustration.

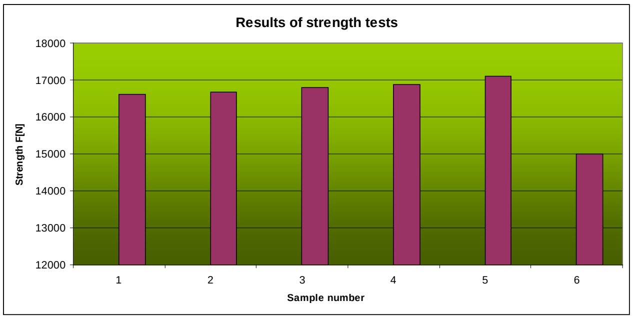

Fig. 4. The diagram of the details strength for various circulating scrap proportions

3. Summary and conclusion

Literature research related to the process of manufacturing high quality die casts of aluminium and silicon alloys causes numerous problems. There are many factors which influence the final quality of a detail. The frequent problems are: proper designing and producing the casting mould, cast alloy preparation, selection of die casting parameters etc.

In the X-ray inspections for the details produced porosity has not been detected in tests 1÷3. In samples 3 and 4 a little porosity occurred, although the number size of pores, their distribution and location in the cast are acceptable for the ordering party. However, in samples 6.2 and 6.3 the porosity detected exceeded the permissible value for the detail. On the basis of the X-ray inspections analysed it may be stated that porosity appeared in the detail for the metal input and circulating scrap proportion of 20%-80% (No. 6, Table 4).

The research done has shown that the porosity exceeds quality requirements when the metal input and circulating scrap proportions of 20%÷80% have been applied. The porosity occurred on the thicker sides of the cast picture (Fig. 2, sample

No. 6). Test No. 5, again with the proportion of 40% of the metal input and 60% of the circulating scrap, demonstrates lack of porosity, which proves that this proportion is a configuration safe for the details quality in terms of porosity.

The static strength test let the author estimate the influence of the addition of the circulating scrap on the product endurance. The best results on the basis of research done have been received for the tests No. 1-5 (16569÷16780 N). Sample No. 1 may be treated as the referential one. On the basis of the Table 5 it may be seen that including the circulating scrap contributed to the growth of the maximum tensile force F_{max} for samples 2-5. For the test No. 6 the result was significantly worse than the rest, which was 14986 N and does not fulfil the strength criterion for the detail given.

On the basis of the X-ray inspection and strength tests it may be stated that the best results have been received for the proportions 1÷3. For tests 1÷3 porosity has not been reported and the results of strength tests fulfil the criterion. A little porosity in samples 4÷5 has not influenced the details strength and the addition of the circulating scrap has contributed to the growth of the maximum tensile force. Introducing 80% of the circulating scrap has caused great porosity which led to reduce the strength of the detail.

The proportion of 40% of the metal input and 60% of the circulating scrap (test No. 5) is a configuration safe for the details quality in terms of porosity and mechanical strength.

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