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DISCREPANCIES ANALYSIS OF CASTS OF DIESEL ENGINE PISTON

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The essential material requirement for pistons concerns its parameters at different piston working temperatures at different ambient temperatures. The study employed penetrating tests in quality control of diesel engines used in passenger cars. The aim of the research was to determine the sources of casts discrepancies detected in penetrating test, using traditional quality management tools. Ultimately, the conducted analysis was aimed to reduce the number of non-compliant products or their total elimination.

Keywords: piston silumines, engine, penetrating tests, quality management tools, silumin products

INTRODUCTION

The dynamic development of technology affects the continuous increase of the loads of used machines and devices, which results in an increase of materials requirements. [1-9] Development of new and improvement of existing casting alloys - in terms of specific physicochemical properties as well as functional features, is one of the most important directions of global casting development at the beginning of the 21st century [10-11]

Piston silumines

The alloys of the aluminum-silicon system with additions of other elements are called silumin alloys. Due to the purpose and scale of production, in this group of aluminum alloys there is an important, specialized subgroup - piston silumines [12, 13].

Silumines designed for pistons of combustion engines are an example of one of the most complex casting metal materials, in terms of chemical composition. They are alloys from the system Al-Si-Cu-Mg-(Ni)-(Mn)-(Fe)-(Zn), sometimes supplemented by: Cr, Co, Mo, V or W - as alloy additions or Na, K and Sr – as modifiers of silicon eutectic and Sc, Ti, Zr, V, B - grain grinders, αAl- solid solution and S, P as modifiers of primary silicon crystals (βSi). In brackets of the given generalized marking of piston silumines, elements are included that can be classified as desirable alloy additives as well as impurities.

In specialistic publications, suggestions for introducing of other alloy additives, modifiers or grain grinders to piston silumines from other elements of the periodic table, eg La or Ce, can be found [11, 14-15].

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ANALYSIS

Characteristic of the B2 alloy

The tests were carried out on pistons made of B2 alloy, which is an eutectic aluminum alloy with silicon intended for pistons for diesel and gasoline engines used in light vehicles. The chemical composition of the B2 alloy as well as physical and mechanical properties can be found in the subject literature, eg. [16-18].

Research goal

The aim of the research is to determine, with the help of traditional quality management tools, the sources of discrepancies of casts (from B2 alloy) of diesel engines pistons used in passenger cars and ultimately, to reduce the number of non-compliant products or their total elimination.

Subject of research

The subject of the research was a piston designed for a diesel engine used in passenger cars. The 3D model of the diesel engine piston is shown in Figure 1. The pistons are produced in one of the plants in the south of Poland.

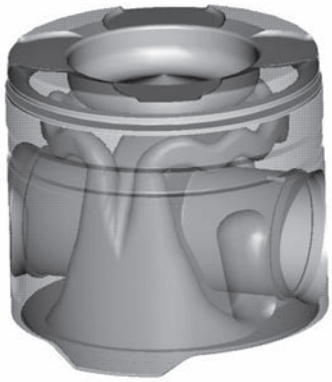

Figure 1 Subject of research - 3D model of a diesel engine piston [16]

Research methodology

Penetration tests were performed in a specially adapted room. They were performed after mechanical machining of pistons.

Samples for metallographic examinations were cut out of defective areas of the piston casting by a metallographic cut-off machine, then they were embedded in the resin, after which they were grinding and polishing on the Saphir 530 device. Metallographic microsections were pickled with 5% aqua solution of HF acid. Observation of the microstructure was performed with use of a metallographic Zeiss Neophot 2 microscope.

RESULTS OF ANALYSIS

An exemplary result of the penetrating test of a bolt hole of a diesel engine is shown in Figure 2.

The obtained penetrating tests results indicate that there is an uncovered disadvantage of about 1,2 mm in the medium loaded zone (lower part of the bolt hole). The localized discontinuity disqualifies the piston, therefore, samples were taken from areas of discontinuity and metallographic microsections were made.

The results of metallographic observations are presented in Figure 3.

The occurrence of the observed discontinuity causes that such a piston becomes an incompatible product.

Figure 2 The result of penetrating test of the bolt hole of the diesel engine piston [16]

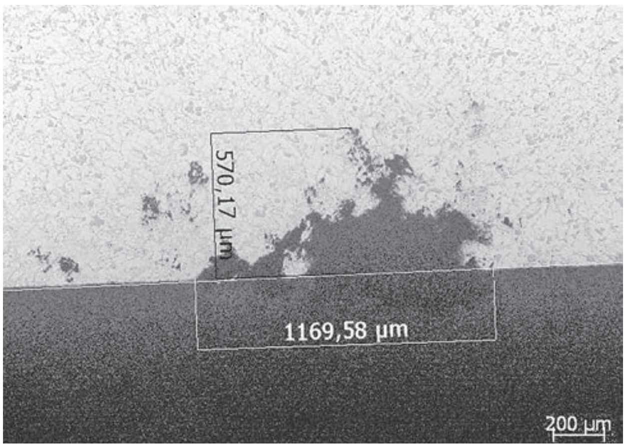

Figure 3 Microstructure of the material of the piston bolt hole in the area of discontinuity [16]

Table 1 **Types and number of discrepancies of the piston casting in the examined period of time**

Discrepancy number	Discrepancies amount	Percentage share / %	Cumulated value / %	Discrepancy description
1	110	35,60	35,60	Microshrinkages presence
2	91	29,45	65,05	Oxides presence
3	42	13,59	78,64	Remains of molding sand in a casting die and aluminum contamination
4	23	7,44	86,08	Misrun
5	18	5,83	91,91	Damage of filtration sieves in a vat or in overflow system
6	11	3,56	95,47	Contraction cavity
7	7	2,27	97,73	Damaged filling pipes
8	3	0,97	98,71	Uneven cooling of a casting die
9	3	0,97	99,68	Too slow or too fast pouring into mould
10	1	0,32	100	Overheating of the material after crystallization
Sum	291	100		

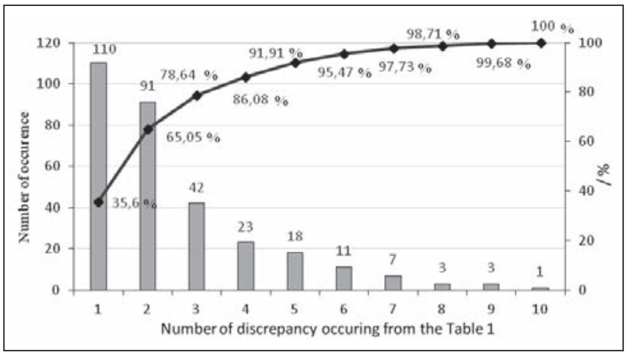

Figure 4 Pareto-Lorenzo diagram for discrepancies occurring in the piston of the diesel engine

This fact shows that the penetrating test method can be a tool for pistons' quality assessing. A separate issue is the issue of analysing and preventing from non-compliant products.

PROPOSAL OF IMPROVEMENT

The proposed instrument for the analysis of the defectiveness of the product was the Pareto - Lorenzo analysis [19] aimed at identifying the most significant discrepancies from the point of view of their occurrence. Table 1 presents the types and amount of all discrepancies of the product, on the basis of which the Pareto-Lorenzo diagram was made, which is shown in Figure 4. Data for the tests came from the batch of products ending 2017 and collected for a period of 6 months. The second stage of the product defect analysis was the analysis of the discrepancies causes using the Ishikawa diagram [20]. Figure 5 presents the factors affecting uprising of one of the most important for a company pistons' discrepancies - presence of microshrinkages in the piston's casting.

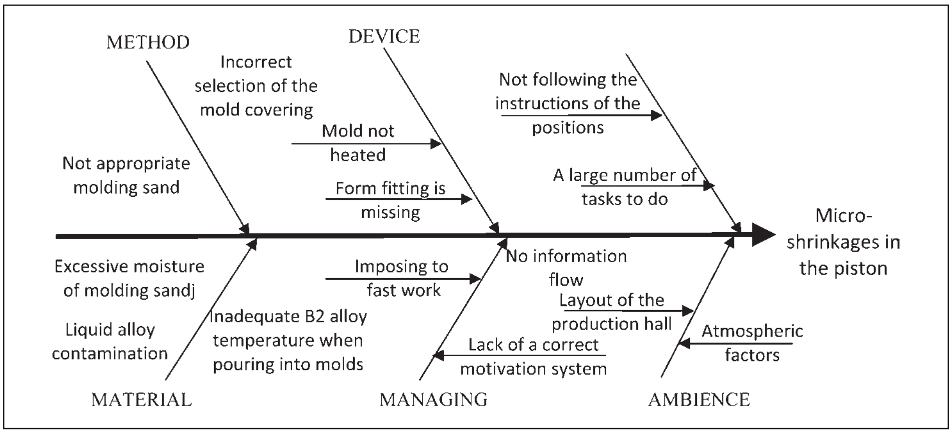

Figure 5 Ishikawa's diagram of causes of microshrinkages presence in the piston casting

CONCLUSION

On the basis of diagnostic tests and analysis of the diesel engine piston, made by penetrating method, attempts were made to identify the causes of discrepancies for their further skillful removal.

The analysis carried out using the Pareto - Lorenzo diagram showed that the most important discontinuities were the three types of discrepancies, i.e. presence of microshrinkages in finished castings (35,60%), oxides (29,45%) and molding sand oddments in the casting die as well as aluminum pollution (13,59%). They cause 78,64% of all non-compliant products in the piston casting process. To significantly increase the quality of production, attention should be firstly paid to these discrepancies. Their sources should be found and an attempt to eliminate them should be made.

While analyzing the Ishikawa diagram (Figure 5), it can be concluded that among the most important factors affecting the formation of microshrinkages in the discussed piston casting, the one associated with piston material was distinguished. In this group, the most important was the contamination of the liquid alloy and the inadequate temperature of the B2 alloy during casting into the molds.

The use of presented tools can allow to precisely reach the source of problems in the piston production process and skillfully raise its quality.

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Note: The English Language translation was done by Beata Hircová, Košice, Slovakia