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Typical Quality Defects of the „Alphin" Inserts in Engine Pistons

J. Piątkowski [a, *], P. Kamiński [b]

[a] Silesian University of Technology, Faculty of Materials Science, Krasińskiego 8, 40-019 Katowice, Poland
[b] Kamsoft – Joint Stock Company, 1-May 133, 40-235 Katowice, Poland
*Corresponding author. E-mail address: jaroslaw.piatkowski@polsl.pl

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Abstract

In the dissertation, the 5M Method, is being presented, of typical causes and consequences of quality defects of cast-iron inserts „alphin" embedded in aluminum cast. The diffusive connection of those rings, with pistons casts is being used, because of the extreme conditions in which they need to operate in, which are of high temperature and variable thermo-mechanical burden, which are in the working chamber of combustion engine.

Keywords: Al-Si cast alloys, „Alphin" inserts, Engine pistons, 5M and 5 Why Method

1. Introduction

For many years now, in Poland and throughout the World, the casts combining the properties of two different metallic materials that are called bimetallic casts [1, 2]. These are the materials with embedded cast-iron or steel inserts in Aluminum alloy [3, 4] with permanent diffusive connection between them. The bimetallic casts are having high durability and tribological resistance of cast-iron or steel as well as good heat conductivity of aluminum alloys connected with their low density [5]. The bimetallic casts are also proving themselves, when low weight of the cast is required and fast heat removal. Enlisted requirement must be met by the parts of the machines, which has wide use in motorization and aircraft industry for: sleeves of combustion engines, drums and breaking plates for the cars, pistons of combustion engines (grooves of the sealing "fire" ring). The method of production of these elements with embedded cast-iron or steel insert in Aluminum cast is being called the Alpher process [6, 7]. This process depends on getting on properly prepared insert (cast-iron ring), the diffusion layer as a result of immersion process of alphination, and then, removing it from aluminum bath and fast casting the alloy to the crucible [3÷7].

2. Scope and purpose of research

The aim of the study was the analysis of the most important causes and consequences of quality defects of „alphin" by the method of 5 Why and 5M (Ishikawa Diagram) inserts on the castings of engines pistons casts.
In order to achieve the assumed goal, the scope of the study is, between the other:

- production stages of „alphin" inserts, and their installation in the pistons,
- identification of the problem of quality defects manifestation,
- defining the causes and consequences of the quality defects of "alphin" rings with the method of 5 Why,
- a Ishikawa Diagram (5M method) preparation (man, method, machine, material, management,
- the responsibility for discovered casting defects,
- quality control methods of "alphin" inserts quality defects,
- proposal for improvement directions in order to limit the volume of defects,
- analysis of the results and summary.

3. Research method

The analysis of quality defects of cast-iron „alphin" rings and combustion engines pistons had been started with the description of the production process of the insert, being done with milling, shot penning, embedding the insert in the piston cast, alphination process of the inserts and quality control for the connection between "alphin" coating with piston material (AlSi). For the research the Ishikawa Diagram [8].

4. The results of the research

A typical quality defects are, between the other: cavities in „alphin" insert and on connection with the piston, metallic and non-metallic inclusions beside the insert, lack of adherence of "alphin" insert, improper diameter of the insert and shrinkage porosity holes on the connection with the piston (Fig. 1).

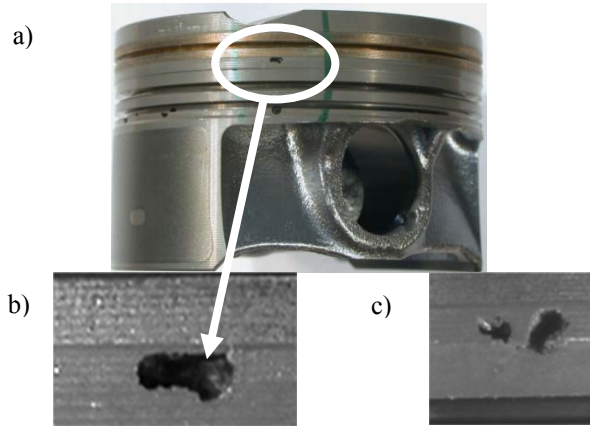

Fig. 1. The typical quality defects „alphin" and pistons

Block diagram of preparation process of „alphin" rings to the point of storing them on the cast stand is shown on Figure 2.

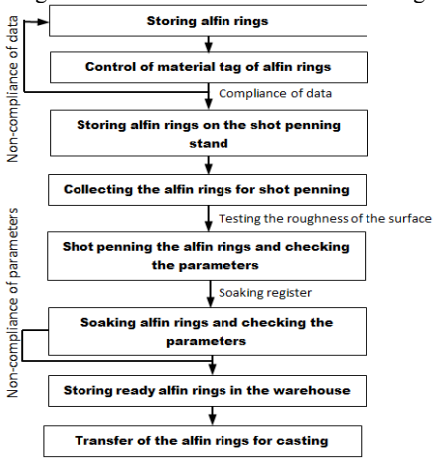

Fig. 2. Block diagram of „alphin" inserts preparation process

Considering all the stages of „alphin" inserts preparation, in the first part the „5 Why" (5W) method has been shown, in order to identify the causes and consequences of quality defects of those rings. The results are being shown in Table 1.

Table 1.
The causes and consequences of quality defects of „alphin" inserts with the 5W method

5 Why				
Main Causes – the MAN				
1 Why	2 Why	3 Why	4 Why	5 Why
Dirty insert - oil	Carelessness and omissions	Low motivation	Low salary	High cost
Improper packing of the insert	Lack of engagement	Monotonic work	Serial production	Volume of order
Main Causes – MACHINE				
Improper roughness	Improper processing settings	Old machines	Lack of investment	High cost
Improper dimensions of the rings	Machine failure	Lack of check-ups	Belittling the problem	Lack of losses awareness
Improper shape (radius)	Machines accuracy	Mistakes of the programmer	Numerous mistakes	Frequent haste
Improper thickness of the rings	Lack of production automation	High cost	Profitability and investment analysis	Variable production assortment
Blunt milling tools	Fast wearing of tools	Material of low quality	Urge for savings	Lowering the production cost
Main Causes – METHOD				
No automation	Limited investments	Too high cost	Changing market	Technical progress
Underinvestment in machines	Suspended investment funds	Unprofitability of investment	„Make-or-buy" decisions	Lower risk of production loss
Old control-measurement methods	Lack of better method	Limitations	Market risk	Market changes
Improper number on the package	Manual packing	No automation	Too high cost	No profitability
Moistening while packing	Atmospheric falls	Plant structure	No change of posts	High costs
Using visual control	No additional tools	Lowering the costs	Profitability increase	Orientation on profit
Obsolete measurement methods	Too many shortages	Low efficiency	Lack of investments	Lack of need for change
Improper markings on the inserts	Great omissions	Monotonic work	No rotation on posts	Bad management
Main Causes – MATERIAL				
Rings and pistons material defects	Damages during mechanical processing	Machines breakdowns, stoppages	Lack of continuous super-vision over the machines	Often omissions and negligence
Main Causes – MANAGEMENT				
No machine investment	No funds and repairs	Old machines	No investments	Stormy decisions
Manual operations	Ill process org.	Ill transport. organization	No selfconcio--usness	No trainings
No synchron. with the supply	No ordering nor planning system	No supervisor	Limited employment	Too high man--agement cost
Bad location of the cast house	Ill infrastructure	Bad management	Corporation limitations	Corporate philosophy
Moistening and soiling during the transportation	Open air transportation	Great distance from the cast house	Bad logistics management	Team of not trained people

After defining the causes and consequences of the quality defects of „alphin" rings with the 5W method, the Ishikawa

diagram was prepared. Because of too elaborated volume of occurred cause-consequence connections, the diagram has been divided into 5 categories of causes (as per the 5M rule), which are: man, method, machine, material and management [9].

Main causes and sub causes of quality defects of "alphin" rings that are located in combustion engines pistons are shown on Figures 3 to 7.

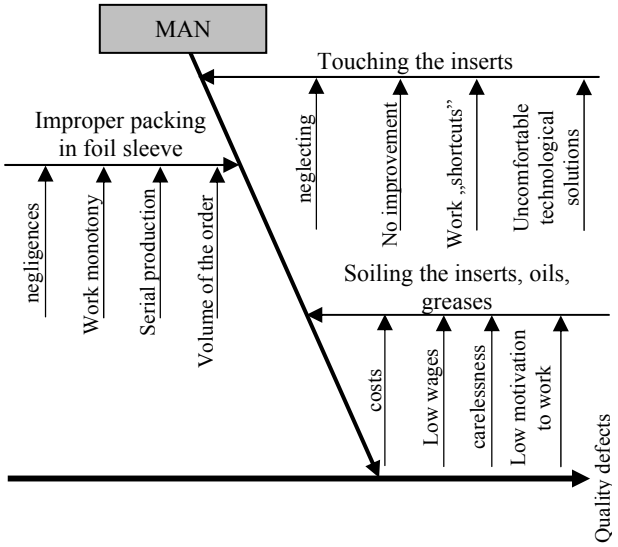

Fig. 3. Part of the Ishikawa diagram – cause MAN

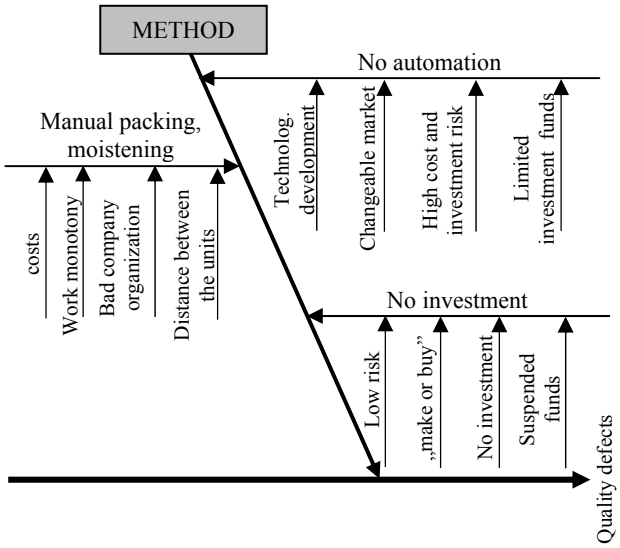

Fig. 4. Part of the Ishikawa diagram – cause METHOD

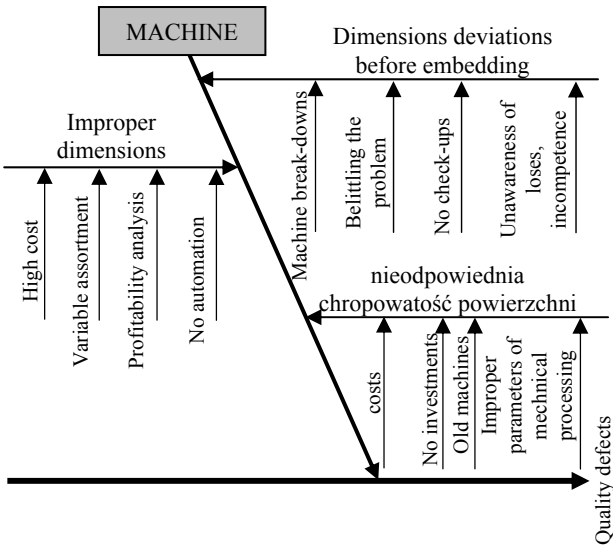

Fig. 5. Part of the Ishikawa diagram – cause MACHINE

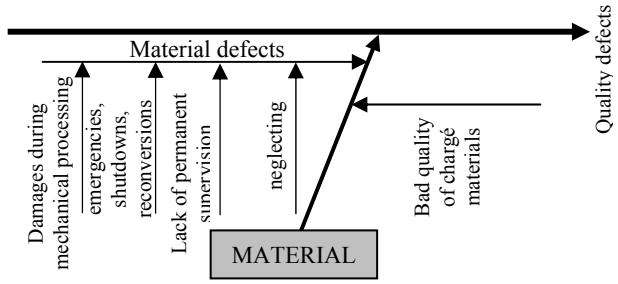

Fig. 6. Part of the Ishikawa diagram – cause MATERIAL

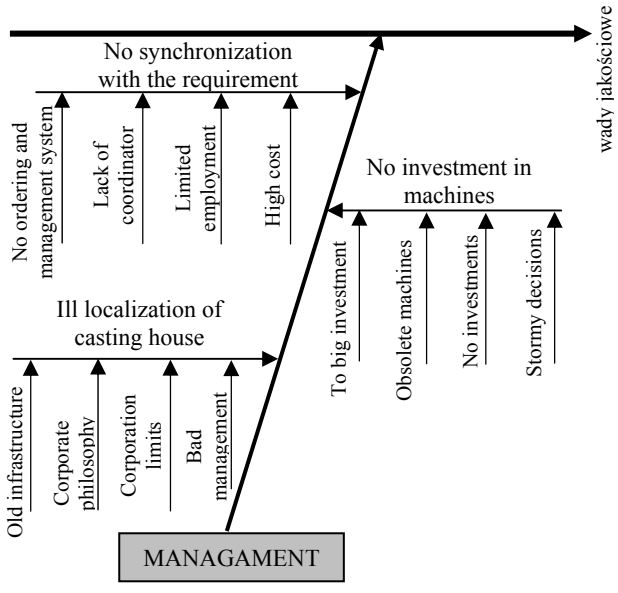

Fig. 7. Part of the Ishikawa diagram – cause MANAGEMENT

5. Summary

During complicated process of combustion engines pistons production, each stage is burdened with many factors that has influence on final quality of the product. Due to the fact, that pistons production is being conducted manually and automatically, the problem of multi-stage process is the human factor and mortality of machine park.
The human factor may be in this case each interference of an employee while pistons production is pending: alphining process, embedding the insert, fixing the mould etc. Some habits of the employees should be noted carefully, since they has the impact on bad quality of the product. So the problem is not only because of the employees, but also it comes from work organization on the working posts, where the key activities are being done. In spite of conducting periodical trainings to improve the qualifications and awareness of the employees, many quality defects are often repeated. Another important aspect, while handling the cast iron inserts are „hygiene" aspects. The aluminum casting house is heavily dusted and polluted, and the storage mode of such a susceptible inserts is improper. It goes especially for the conditions, where salt vapors are in the air, and the air is moist.

The 5W method has been applied for the analysis of the causes and consequences of quality defects of „alphin" rings. The method covered two aspects:

- considering the causes of quality defects appearance,
- defining, why the problem hasn't been found earlier?

During the first stage of the analysis the information about occurred problems of quality defects of „alphin" inserts in combustion engines pistons were gathered. Then, so called "expert group" was gathered and through the brainstorming session they helped to indicate and define the causes of the quality defects. Individual stages of production were described, as well as the embedding process of the „alphin" rings in the piston material (Fig.2) and the occurring problem was described in details, with the help of defects pictures (Fig. 1). As next stem, five questions were asked to the identified causes of quality defects in the area: man, machine, method, material and management (Table 1).
On the basis of defined causes and consequences of quality defects of „alphin" inserts, with the use of 5 Why method, the Ishikawa diagram has been prepared. Due to too wide character of causes and consequences of „alphin" rings, the diagram was divided along the defined main causes of inserts quality defects. The results were shown on Figures 3 to 7.
The last stage of cause-consequence analysis of found quality defects in „alphin" inserts is defining the improvement proposals.
For the causes of human factor there are:

- maintaining hygiene while touching the inserts,
- higher carefulness of blue-collar employees,
- work motivation through the bonuses and prizes financial,
- higher awareness of responsibility through intensified trainings of "common responsibility",
- more frequent controls of casts quality control units.

Worth mentioning is also often repeated mistake of the operator, although, as the shown in the references [8, 9] in most of the cases, the true reason of human mistake lies on bad system, organization or work method.

In the area of method cause the following was proposed:

- substituting manual operations with process automatization,
- the location of „alphin" inserts storage closer to the casting,
- automatic fixing of the inserts in alphinization process,
- logistic improvements of internal transportation.

In the area of machines causes, the proposals were as follows:

- carefully checking up the dimensions and shapes tolerances,
- periodical checking up of the surface roughness,
- exchange of the old machines for modern ones, eventually investing in new parts for casting machines.

In the area "material" the angles towards limiting the defects are:

- more often testing of charge materials quality and/or materials purchased from outside, (the analysis of chemical content of cast iron and aluminum moulds),
- supervision and control over the melting and casting parameters,
- the use of new milling tools during mechanical processing of „alphin" inserts and pistons.

In the area of management it was proposed:

- synchronizing the production process with the volume of the order,
- the use of computer-aided planning and product storage process, the ABC method,
- to introduce the employees motivation methods,
- change or modernization off the unit infrastructure,
- investment in new machinery,
- obtaining new financial means, e.g. from UE structural investment funds.

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