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WYDZIAŁ MECHANICZNY TECHNOLOGICZNY

Rozprawa doktorska

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„Technologiczne metody ograniczenia zużycia stopu do alfinowania wkładek pierścieniowych w odlewach tłoków silników spalinowych”

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"Technological methods to reduce alloy usage for alfining ring inserts in combustion engine piston castings"

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Dissertation abstract

The paper describes the design of pistons for internal combustion engines : Diesel and gasoline, as applied to different applications (depending on the cylinder diameter) and the most important components, including in particular piston ring inserts, the so-called "alfin". The important role of alfin inserts in different piston castings depending on the type of engine, its power, type, etc. In order to understand the issues and complexity of the research undertaken, a full analysis of the so-called "alfining process" of cast iron inserts was made with a breakdown of the stages of their production: From the preparation (shot blasting and heating), microstructure evaluation, to the technological parameters of the piston casting process and the subsequent stages of their quality control. The most common defects in the area of the ring carrier - piston interface, ways of detecting them and the reasons for their formation were analyzed. It was found that during the alfining of inserts in AlSi9 alloy (the so-called AS9), there is an exceeding of the permissible content of iron and non-metallic impurities, mainly oxides and hydrides. As a result, unfavorable morphological phases of β-Al_5FeSi crystallize, which, combined with gas porosity, negatively affect the durability of the connection between the insert and the piston casting. On this basis, the objectives, scope of research and the thesis of the study were formulated. Each of the listed areas included multi-stage tests confirmed by a series of tests under laboratory and industrial conditions. The course of action and testing methodology were adopted according to the standard production of piston castings at Federal-Mogul (F-M) Gorzyce and applicable industry standards. The basic research was divided into three main stages:

1. Optimization of the temperature of AS9 alloy during alfining of ring inserts.
2. Introduction of manganese addition to AS9 alloy to change the morphology of β-Al_5FeSi phases.
3. Future research directions for increasing the yield of AS9 alloy.

In the first chapter of the fundamental research, a new optimal alfining temperature for AS9 alloy was determined from 770°C to 750°C. For the selected parameters, tests were carried out under industrial conditions on 10,000 pcs. Tests proved the absence of an increase in defective products and the fulfillment of all quality criteria for the joint: liner - piston. Based on calculations of input materials, a reduction of about 30% was shown. The second chapter dealt with the application of manganese addition to AS9 alloy to reduce the occurrence of morphologically unfavorable β-Fe phases. An extensive and detailed chapter was devoted to the ATD analysis of AS9 alloy for different iron and manganese contents. The characteristic crystallization temperatures of the identified phases were determined. It was found that manganese causes crystallization of the α-$Al_{15}(Fe,Mn)_3Si_2$ phase instead of β-Al_5FeSi, which does not adversely affect the diffusion connection between the ring carrier and the piston. The research was verified under production conditions.

The final stage of the work was the future directions of development and optimization in terms of increasing the share of recycled materials for the production of aluminum alloys used at F-M Gorzyce, as well as increased and automatic control of the growth of impurities in them.