REVIEW REPORT

of scientific adviser,
Professor of the University of Lorraine (France),
PhD Michot Gerard
on the dissertation work by Dastan Rakhmetollayevich Aubakirov
on the topic "Developing and Studying Technology of Producing Wear-resistant Iron Castings with the Use of Modifiers"
submitted for awarding Doctor of Philosophy degree (PhD)
in specialty 8D07203 – Metallurgy

The dissertation work of Dastan Rakhmetollaevich Aubakirov is dealing with studying the effect of boron and barium-containing modifiers on the structure and properties of low-chromium wear-resistant cast iron and developing the technology of producing wear-resistant iron castings with the use of modifiers.

Today, one of the most pressing problems in present day mechanical engineering is still increasing the service life of wearing parts and technological equipment units, on which solution the technical and economic efficiency of production directly depends as a whole.

Castings and parts made of wear-resistant alloys are in high demand among all kinds of consumers around the world for timely maintenance and repair of equipment and machinery. This is mainly caused by increasing the production rates and the limited service life of parts due to the peculiarities of technological processes and their operating conditions: high temperatures, abrasive and shock loads, an aggressive environment.

Thus, the task set by the candidate for the degree in developing the technology of producing wear-resistant castings of cast iron for parts of mining and metallurgical equipment is urgent and timely.

All the grades of foundry wear-resistant cast iron can be conventionally divided into two main groups. The first group includes alloys used for the manufacturing castings parts for technological equipment in the mining and metallurgical sector (sand pumps, linings, impellers, etc.). The second group is cast iron for casting grinding bodies for grinding ore and other materials to the desired fractional composition in drum mills.

The performed literature analysis revealed that in terms of operational properties, Kazakh balls are inferior to foreign ones by at least 15-25 %. The reason for this is the ideology of making balls using cheap raw materials, which allows ensuring the minimum cost of metallurgical treatment but negatively affects the grinding performance of ore. The technology of casting high-quality balls

alloyed with boron, barium, nickel, molybdenum, titanium additives used abroad is not used in Kazakhstan since it is associated with significant economic costs.

This work proposes another, more rational approach to solving the problem of low wear-resistant properties of Kazakhstan grinding products: microalloying and modifying low-alloy cast iron with available but highly effective additives of local production. Boron- and barium-containing ferroalloys made by scientists from the Bor laboratory of the Zh. Abishev Chemical-metallurgical Institute (Karaganda, Kazakhstan) using domestic raw materials are used as microalloying additives. Boron and barium are currently among the most effective alloying and modifying elements. To achieve the set goals, they are sufficient in metals at the level of 0.001-0.005 %, which characterizes them as microalloying additives. Boron greatly increases hardenability, promotes the production of martensite, increases microhardness and overall hardness, promotes the formation of dispersed reinforcing refractory particles in the structure which increase wear resistance, and reduces the technological temperature of casting alloys. The presence of barium makes it possible to obtain a dense and fine-grained structure of cast iron eventually increasing the strength characteristics of the metal by 10-20 %.

An undoubted novelty of this work is the use of a complex borbarium modifier to obtain wear-resistant cast iron, the consumption of which is at the level of microdoses, which determines the efficiency of the process.

In the course of performing this work, the dissertation candidate carried out thermodynamic studies on the theoretical assessment of phase formation in chromium cast irons with different chromium contents from 1 to 35 %. There are also presented the results of modeling low-chromium cast iron with introducing modifiers containing boron and barium in various ratios. Based on the calculated data, the possibility of the formation of new phases is shown, temperature ranges are given, as well as characteristics of their effect on the structure and properties of the experimental wear-resistant cast iron.

A series of laboratory experiments was carried out for smelting samples of low-chromium cast iron with the chromium content of 1, 3 and 5 % with the addition of various amounts of ferroboron, ferrosilicobarium and borbarium modifier with the following adjusting the dosage of the modifier. The optimal consumption of additives was determined. Experimental work was also carried out to develop various methods of modifying wear-resistant chromium cast irons using the technology of casting according to lost foam casting. Based on their results, the intra-mold method of introducing additives was recognized as the most effective one. The result of a series of experiments is developing a method of producing wear-resistant low-chromium cast iron by introducing modifiers. A patent of the

Republic of Kazakhstan was obtained for a method of producing wear-resistant chromium cast iron.

Using X-ray phase and metallographic analyzes, there was analyzed the microstructure and identified the phases of introducing the experimental alloy. As a result of the studies carried out, the features of the modifying elements effect on the structure and wear-resistant properties of chromium cast iron were described. Laboratories of a number of universities and institutes were involved in the research: KTU (Karaganda), Zh. Abishev ChMI (Karaganda), RTU MISiS (Moscow). A part of the research work was carried out in the laboratory of the Institute J. Lamoure, Lorraine University (Nancy, France).

There was developed a technology of improving the operational properties of low-chromium cast iron castings by modifying the alloy with boron and barium-containing additives. The developed technology of modifying chromium cast iron for balls was tested at the existing production in the conditions of the QazCarbon LLP foundry (Karaganda). High results obtained in previous laboratory experiments were confirmed and noted in the industrial test report.

In the dissertation by doctoral student D.R. Aubakirov there was for the first time given a theoretical assessment of the modifying and microalloying effect of boron, barium and their mixtures on the structure and properties of wear-resistant chromium cast iron for balls and confirmed by industrial results.

The main scientific results of the dissertation work are presented in publications both in the Republic of Kazakhstan and in the far and near abroad. The method of producing wear-resistant chromium cast iron was developed and patented. The publications of D. R. Aubakirov in scientific journals allow getting a complete picture of the scientific and practical results of the doctoral student.

D. R. Aubakirov's dissertation work is a completed scientific and qualification work on the urgent topic; it contains scientifically grounded results, has theoretical and practical value, which are important for metallurgical enterprises.

The dissertation work meets the requirements of the Committee for Control in Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan and doctoral dissertations (PhD), and its author, D. R. Aubakirov deserves awarding the degree of Doctor of Philosophy (PhD) in specialty 8D07203 - Metallurgy.

Scientific adviser,
Professor of the University of Lorraine, Dr. **G. Michot**

INSTITUT JEAN LAMOUR
UMR 7198
CNRS-UHP-INPL-UPVM