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Studies of the transition zone in steel – chromium cast iron bimetallic casting

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Abstract

In this work authors presented the results of transition zone studies on steel – cast iron interface in bimetallic casting. During the investigations cylindrical castings with different diameter were prepared of cast iron with steel rods placed in the center. From each bimetallic casting a microsection was prepared for microhardness tests and metalographic analysis, consisting of transition zone measurement, point and linear analysis as well as quantitative analysis.

Keywords: Bimetallic; Cast iron, Steel

1. Introduction

Technologies of bimetallic casting manufacturing of: steel – cast iron, cast steel – cast iron are often burden with flaws, resulting in improper connection of steel part with the cast iron element, what could lead to failure of the bimetallic casting during its exploitation. A characteristic feature of such castings is the diffusive character of the connection [1]. Proper range of the diffusion ensures the durability and reliability of working element. The aim of presented work was to describe the mechanism of transition zone creation and to determine the factors influencing its size and other parameters. Positive results of the studies would enable optimization of technological parameters of bimetallic casting manufacturing, especially parameters of skeleton castings (cell and connectors dimensions [2] plate thickness in classic bimetallic castings, preheater and working part of the casting dimensions [3,4]).

2. Studies description

During the studies a mould with four thermo-insulating liners (Sibral; 030 L = 150) was prepared, in which steel rods after turning were placed (C = 0,15%) with diameter of ϕ: 5; 10; 15; 20mm and length L = 50 mm (fig. 1)
The mould was then poured with ZlCrlSNiMo chromium cast iron with pouring temperature of 1550°C. The microsections were taken at 16 mm distance from the lower parting of the mould. Then the steel rods were measured (table l, 3. column) and the metallographic analyses were conducted (fig. 2a – 2i).

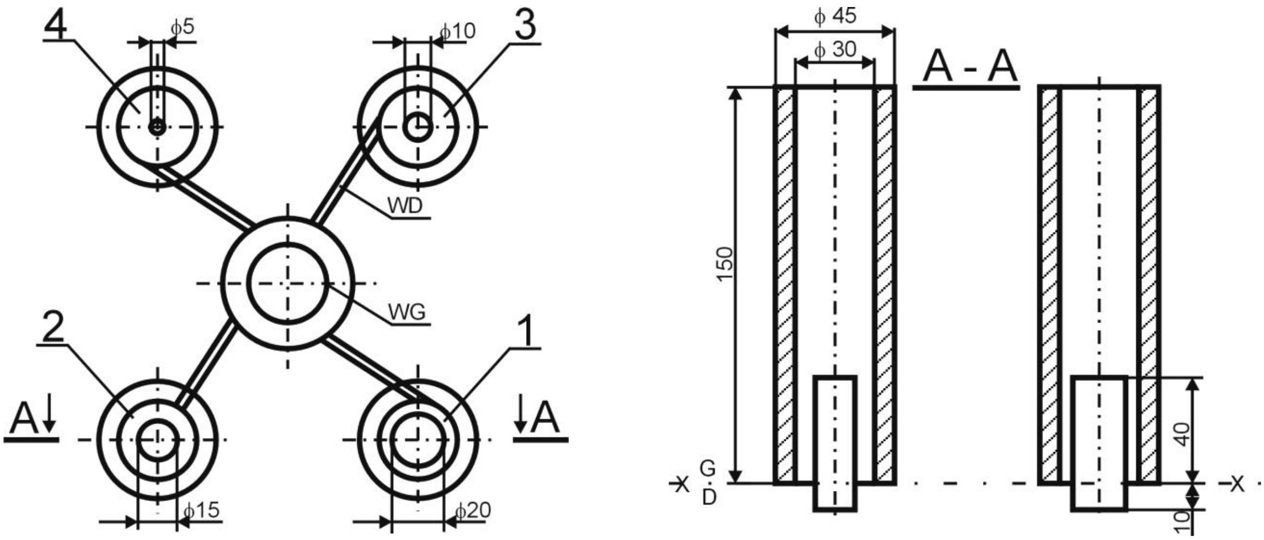


Fig. 1. Scheme for test castings preparation

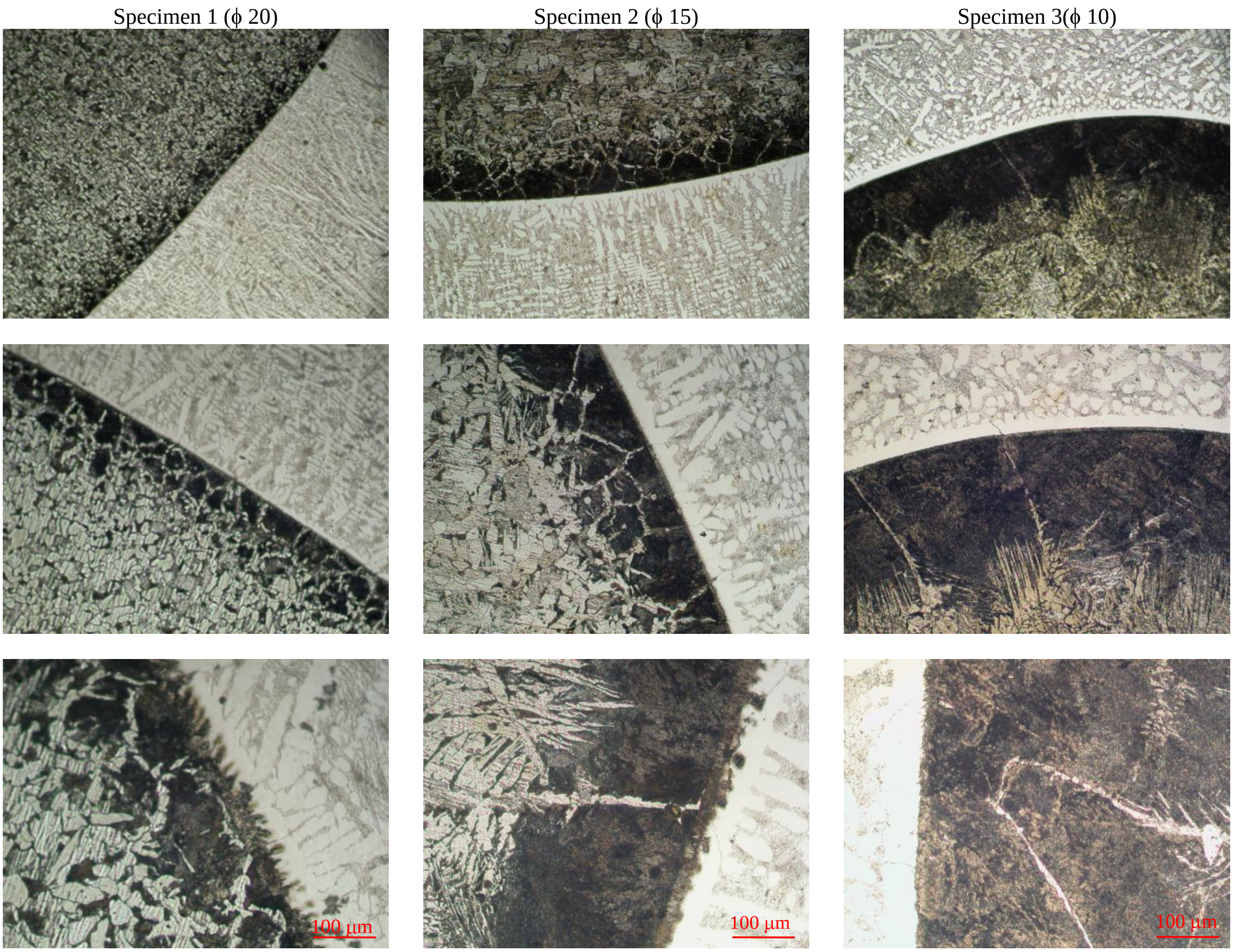


Fig. 2. Examples of connection zone microstructure for 1, 2, 3 specimens at different magnification

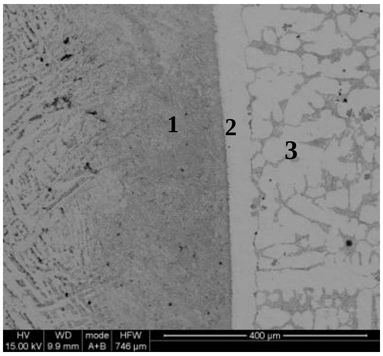
Using computer image analyzer the perlitic layer thickness was measured, as a mean of nine measurements for each specimen (table l, 4. column). Specimen 4 was not measured. Microhardness test for different layers were carried out (at loading P = 65 g):

- perlitic layer μHV = 360,
-decarburizated layer μHV=198,
- cast iron layer μHV = 510.

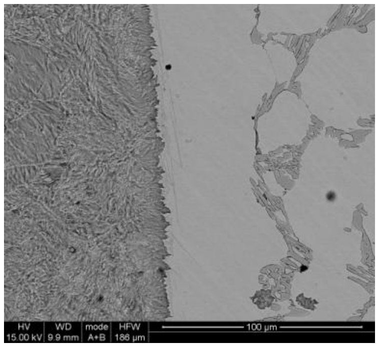
With use of INSPECT-F microscope equipped with EDS detector point, linear and quantitative analyses were conducted for the transition zone of specimen 3. The results are shown in figs. 3 – 5.

Table 1.
Measurement results for steel rods and carburizated layer thickness

Specimen no.	Initial diameter of the steel rod [mm]	Steel rod diameter after pouring [mm]	Average thickness of carburizated layer [μm]
1	2	3	4
1	20	~20	141
2	15	~14	222
3	10	5÷8	437
4	5	0	–



a



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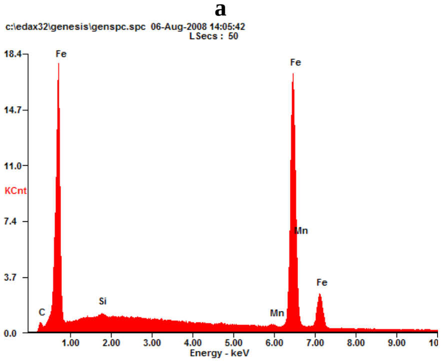

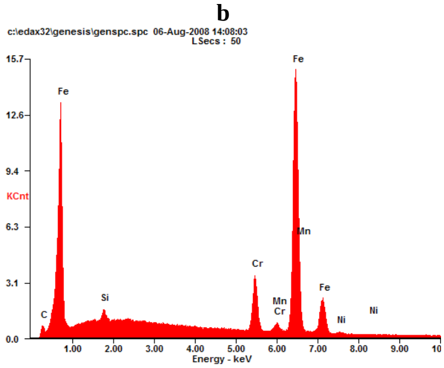

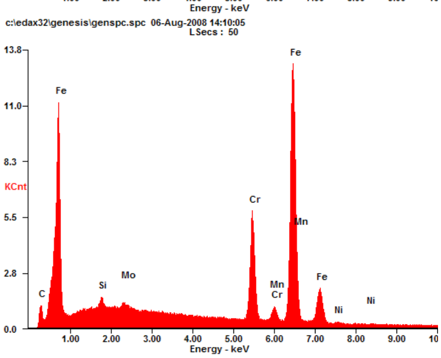

Element	Wt % Region 1	Region 2	Region 3
C K	00.3	00.4	00.7
SiK	00.3	00.7	00.6
MoL	-	-	00.5
CrK	-	09.7	17.8
MnK	00.6	00.3	00.1
FeK	98.8	87.9	79.6
NiK	-	01.0	00.6

Fig. 3. Structure of the transition zone and results of point analysis for specimen 3

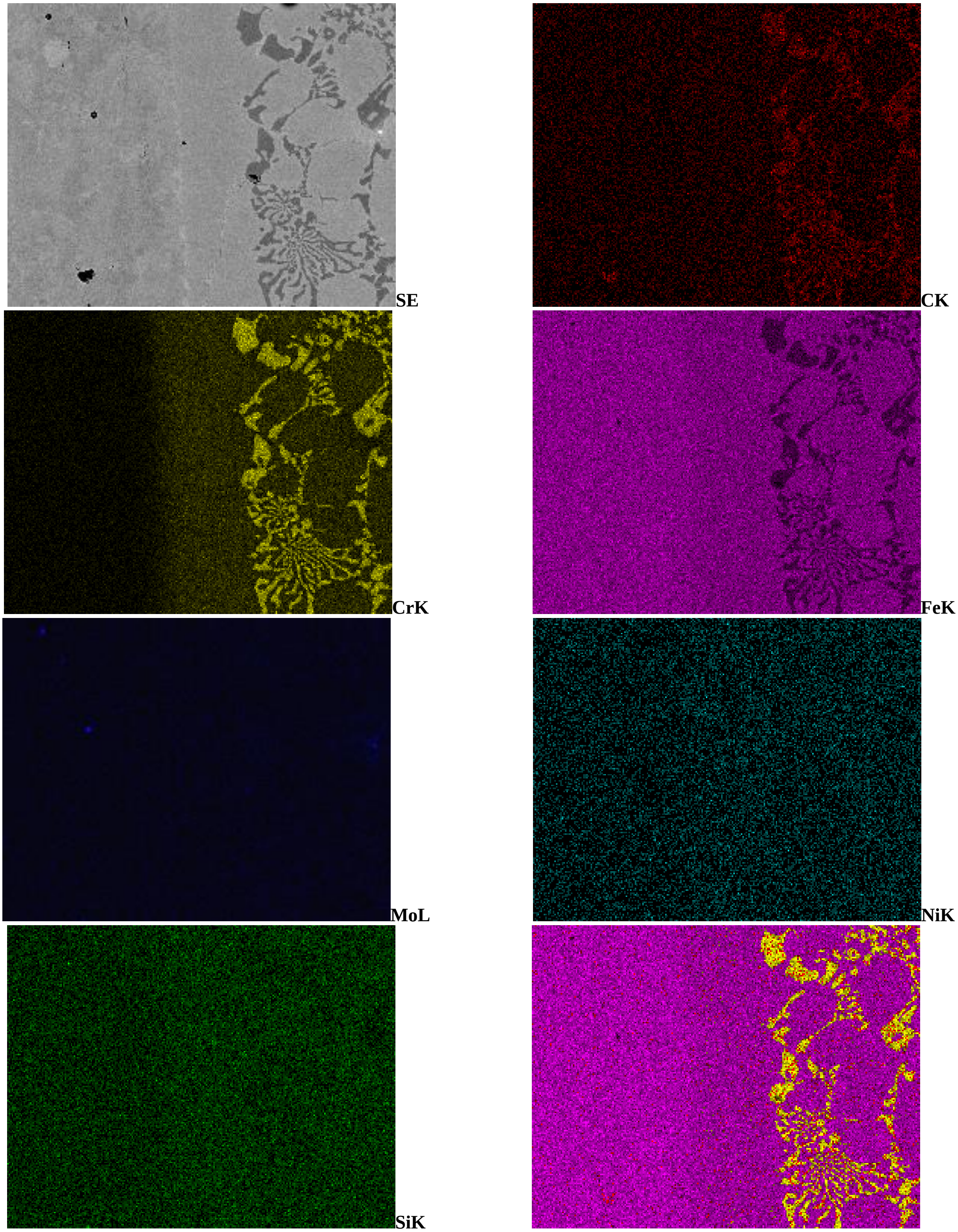

Fig. 4. Elements distribution in the transition zone region for specimen 3

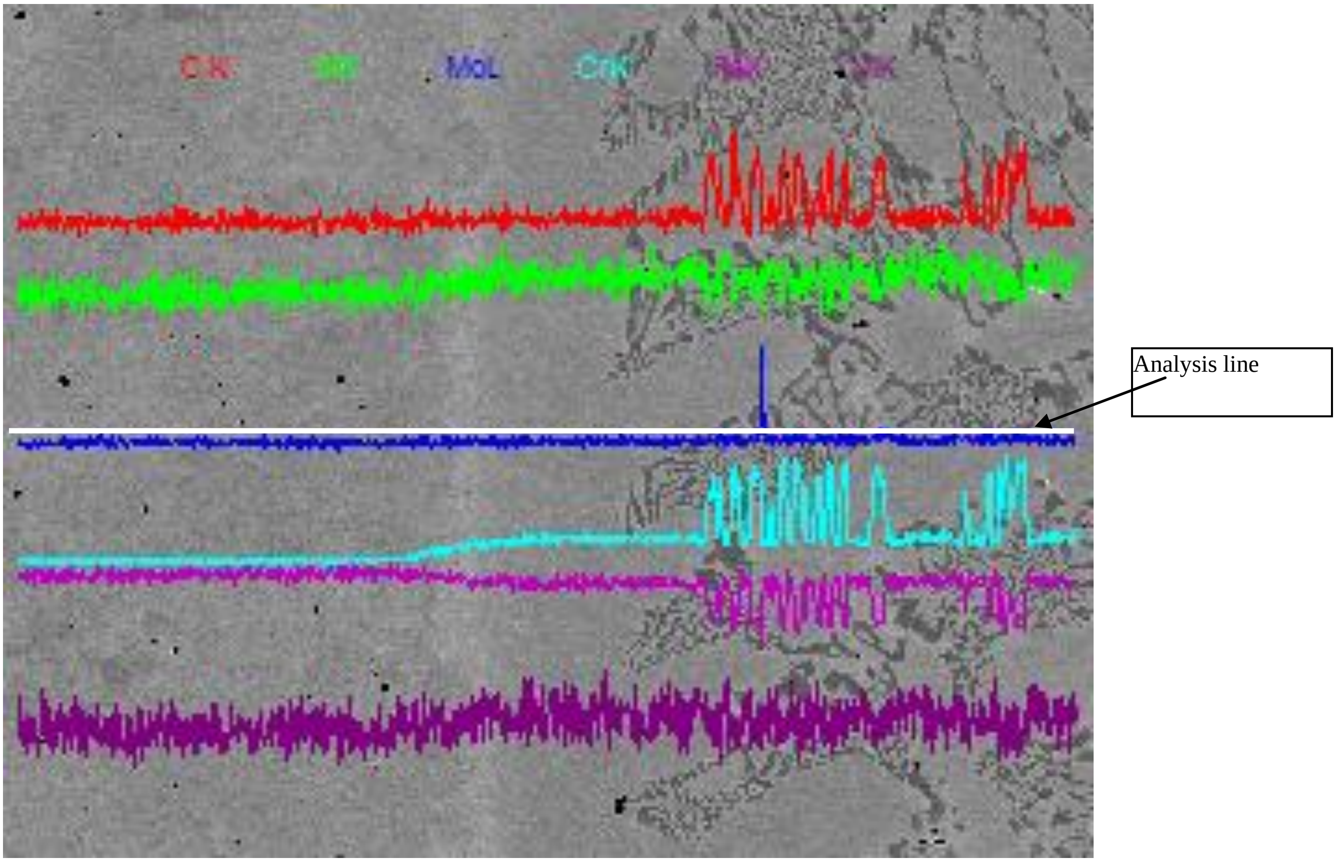

Fig. 5. Linear analysis of elements distribution in the transition zone region of specimen 3

3. Results analysis

Conducted studies clearly showed that the mechanism of connection of steel and cast iron has got a diffusive character. On the interface effects of atoms movement can be observed. In observed region the steel rod dissolves – resulting in change of the rod diameter (tab. 1, 3. column). Diffusion of carbon and chromium results also in creation of secondary phases – decarburizated on the cast iron side and carburizated on the steel side. In the steel rod perlite content increases, due to growing carbon content. The chromium diffusion to the steel rod results in perlite dispersion change.

An important factor influencing the transition zone structure is also the heat capacity of cast iron and steel used. It can be concluded from similarities observed for specimens 1 and 2. A clear zone of ferrite columnar crystals can be observed, resulting from cooling influence of the steel rod. Such zone is not observed for specimen 3.

On the cast iron side a decrease of carbon content is observed, resulting in alloy ferrite zone which thickness is inversely proportional to the steel rod diameter.

For specimen 4 the steel rod was totally dissolved (fig. 6). This points out the significance of heat capacity proportion between both parts of the bimetallic casting.

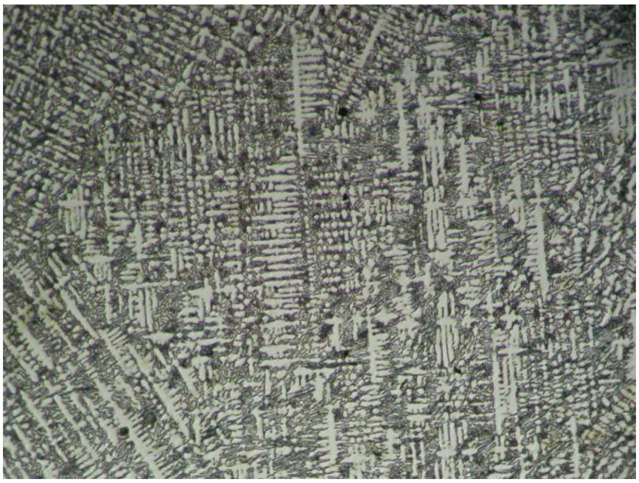

Fig. 6. Structure of specimen 4, steel rod region

5. Conclusions

Conducted studies enabled formulation of following conclusions:

1. To obtain proper diffusive connection it is necessary to select materials with different carbon content, because of its high diffusivity.
2. Transition zone thickness (perlite and alloy ferrite) is related to proportion of heat capacities of materials used.
3. In case of steel rod volume increase it can act as a interior chill.
4. With the decrease in steel rod volume, the possibility of its total dissolution in cast iron increases.
5. Besides carbon in diffusion process of transition zone creation also chromium takes part (perlite with low dispersion).

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