HIGH SILICON CAST IRON WEAR RESISTANCE FOR METAL - MINERAL SYSTEM

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Abstract

The article presents the results of abrasion tests for different types of silicon cast iron. Scope of research included silicon cast iron with a silicon content in the range of 15 - 25 %. Wear resistance studies were based on gravimetric method, where the sample was moving reciprocally in metal - mineral friction system. As a material for countersample silicon carbide was used. Obtained results allowed to determine the wear resistance of alloy cast iron and the relation between silicon content and wear resistanc in the alloy for selected work conditions.

Keywords: Wear resistance, silicon cast iron

1. INTRODUCTION

Selection of appropriate material for castings working in a specific environment and conditions entails a number of challenges for both the constructor and also for technologist and foundryman. It is not enough to design a shape of the element, performance it based on available technologies. Required properties for the casting should be selected in such way that they will ensure correct and safe exploitation. There is literature giving information about corrosion resistance of high silicon cast iron [1-4], while there is no data describing wear resistance of this material. Therefore, the paper discusses a very important issue of assessing the quality of the cast based on abrasion resistance analysis. Such knowledge is important from an engineering standpoint, it provides a lot of valuable information for designers. The results presented in the paper describes wear resistance of high silicon cast iron [5] in sliding friction conditions in reciprocating motion of sample. The samples were abraded in friction pairs metal - mineral. As a material for countersample to tests silicon carbide (SiC) was used because of its high hardness (9 in Mohs scale) [6]. The study was conducted on a prototype test stand, that concept was developed at Department of Foundry, Silesian University of Technology.

2. EXPERIMENTAL PART

2.1. Study material

The samples used in tests were casted in laboratory conditions using an induction furnace and double melting technique [7÷10]. As a charge material to prepare melt steel scrap, ferroalloy FeSi75 and carburizer Ranco were used. Preliminary carburizing of alloy was applied [11].

Table 1 Chemical composition of tested cast iron

Name of samples	*Si (%)	C (%)	S (%)
HSCI 15	15.09	0.43	0.001
HSCI 17	17.14	0.55	0.001
HSCI 19	19.12	0.52	0.003
HSCI 21	21	0.5	0.008
HSCI 23	23.02	0.82	0.007
HSCI 25	25.06	0.12	0.007
* calculated value			

The samples for wear analysis were prepared in shell moulds made in “C” process (Croning’s). A detailed description of experimental stand was presented in the work [7, 12]. In **Table 1** silicon, carbon and sulphuric contents for examined samples were presented. Analysis of carbon and sulphuric content was conducted on LECO analyser.

2.2. Metallographic analysis

Figure 1 shows photos of analysed cast iron microstructure made on optical microscope.

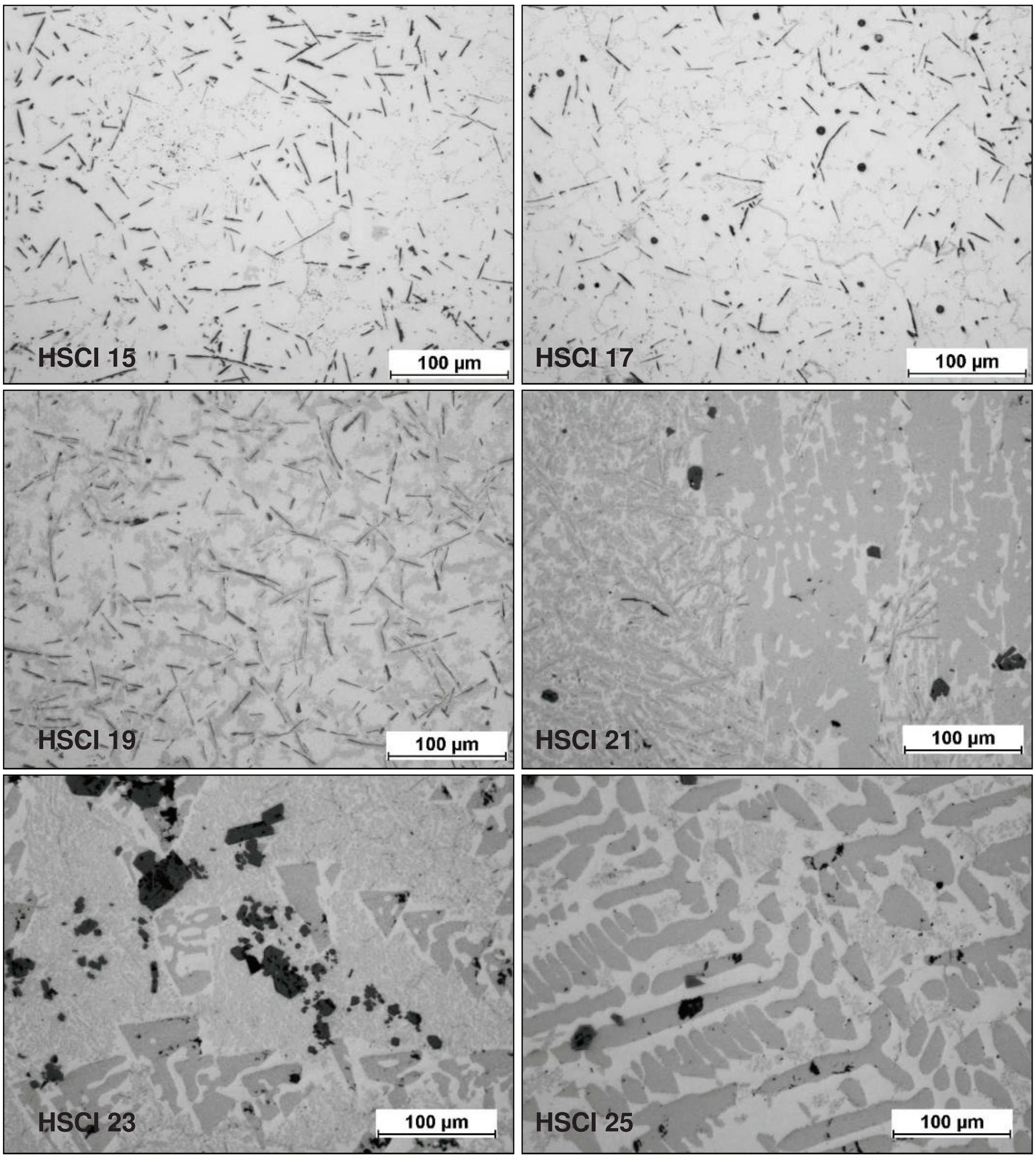

Figure 1 Microstructures of examined cast iron, not etched

2.3. Methodology of study

For the studies the tribological machine was used. The machine is composed of a driving part consisting of: an electric motor, belt transmission, gear transmisson, crank mechanism. Work part includes a jaw chuck, which moving reciprocating (horizontal) and a table with possibility to moving vertically. Table is loaded with the static force set by a system of levers. A view of test stand work part was shown on **Figure 2**.

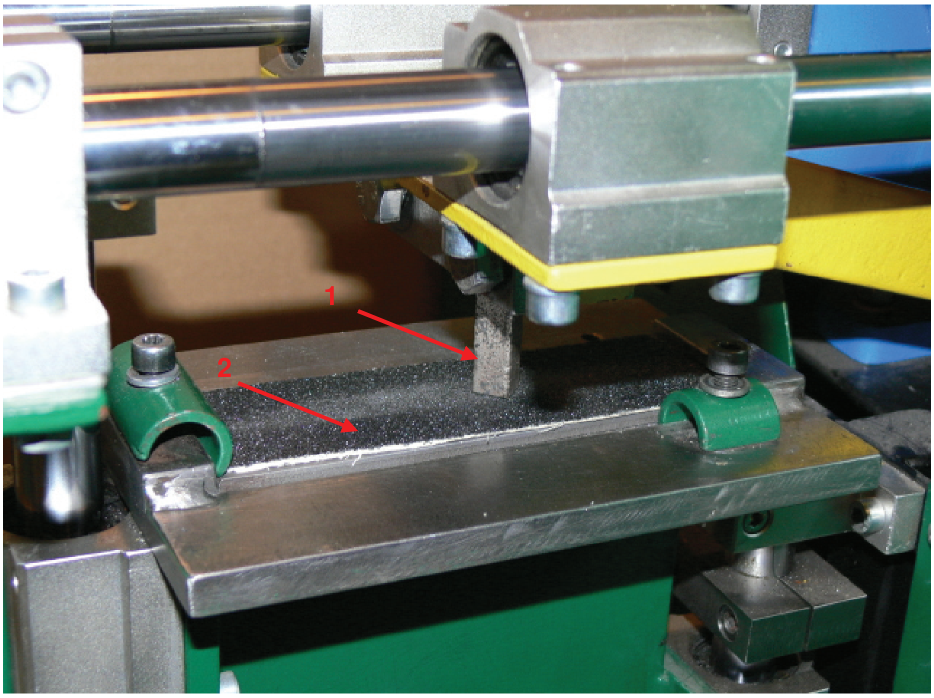

Figure 2 Work part of tribological machine: 1 - examined sample, 2 - countersample

The cross section of tested samples was a square with demensions 10 x 10 mm. This surface was abraded. Each sample was mounted in holder of tribological machine in the same way. Execution of one measurement consisted of measuring the loss of weight of test mateiral after 5000 cycles reciprocating motion of friction pair. During single test series each sample travels a distance of 1000 m with an average speed of 0.6 km / h. As a countersample the silicon carbide with gradation P 50 was used (countersample is shown in **Figure 2** marked with number 2). Countersample has been replaced after 1000 cycles, which was 200 m. Weight of sample was 10 N. For each sample 4 measurements were executed. The surface of all samples was pre-abraded before testing to ensure full contact of test sample with countersample. Measurement of weight loss was made after complete test cycle (distance traveled by sample: 1000 m) using laboratory scale accurate to 0.001 g. Before each measurement the scale was checked using standard weights. Measurement error amounted ± 0.001 g. The air temperature in laboratory during testing oscillated between 22 °C ± 0.5 °C.

2.4. Results of studies

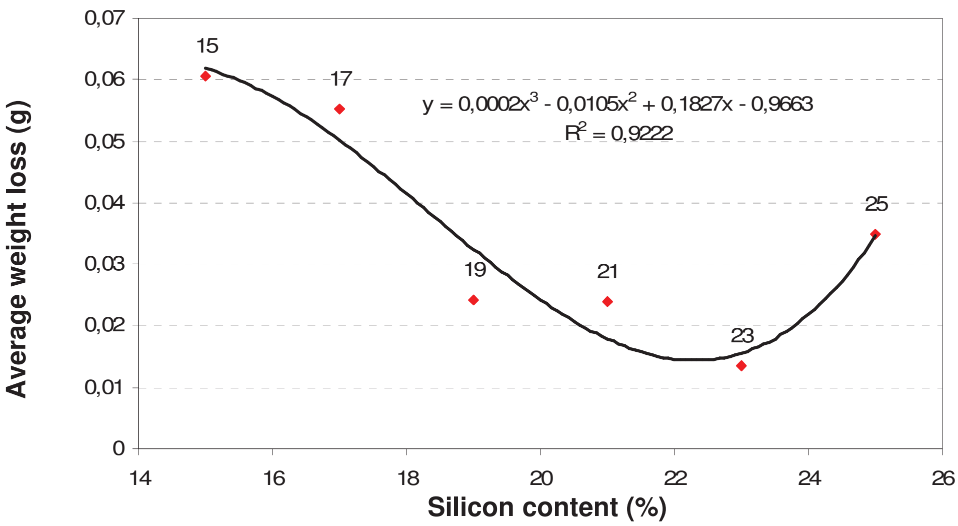

Figure 3 Average weight loss of sample in relation to Si content

Obtained results of studies allowed to made graphic summary. In **Figure 3** the average weight loss of samples in relation to Si content were presented. To obtained values the trend line was determined described by the equation, where the coefficient of correlation amounted R^2 = 0.9222.

On graph in **Figure 3** characteristic inflection around silicon content at 23 % was observed. Since that point increase of Si content in alloy decreases wear resistance sliding friction conditions in reciprocating motion of sample for metal - mineral friction pair. In **Figure 4a** the front surface of sample (HSCI 19) after one complete test cycle was shown. **Figure 4b** presented a view of sample surface obtained using scanning electron microscope Phenom ProX. There are visible fissures and small chipping on the edges of sample due by work of metal-mineral friction pair.

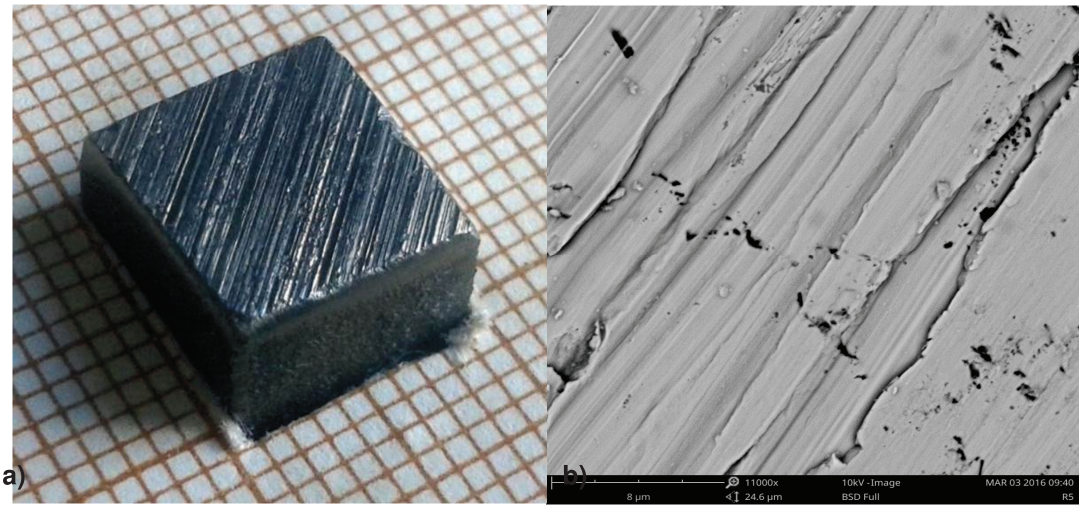

Figure 4 The front surface of sample HSCI 19 after one complete test cycle: a) macro view, b) view from the scanning electron microscope

Analysing the obtained results it can be concluded that the higher silicon content up to critical point (around 23 % Si content) the wear resistance of high silicon cast iron increases. The average weight loss for the alloys HSCI 15 and HSCI 17 compared to HSCI 19 and HSCI 21 was about 50 % larger. Photos of microstructure for the first two alloys show a very small amount of Fe_5Si_3 phase [13÷16], which can be seen on other alloys microstructure. Additionally, there are other intermetallic phases in alloys matrix, for example in HSCI 19 appears Fe_3Si phase as primary precipitates. It can be assumed that they have a part in improving wear resistance. HSCI 25 sample was indicated a decrease of wear resistance in relation to 19 ÷ 23 HSCI samples.

3. CONCLUSION

Based on conducted studies and obtained results the following conclusions were drawn:

- dependence of wear resistance for high silicon cast iron in relation to silicon content is not linear,
- with increasing of silicon content up to critical point (around 23 % Si content) the wear resistance of high silicon cast iron increases,
- characteristic inflection around silicon content at 23 % was observed. Since that point increase of Si content in alloy decreases the wear resistance sliding friction conditions in reciprocating motion of sample for metal - mineral friction pair,
- the increase of wear resistance is associated with the appearance of intermetallic phases, photos of microstructure for the first two alloys show a very small amount of Fe_5Si_3 phase, which can be seen on other alloys microstructure. Additionally, there are other intermetallic phases in alloys matrix, for example in HSCI 19 appears Fe_3Si phase as primary precipitates,
- exceeding the critical content of hard phase in alloy results in decrease of wear resistance.

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