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IMPROVING THE MECHANICAL PROPERTIES OF PARTS MADE OF HIGH-MANGANESE STEEL WITH METALLOID TYPE MODIFIER

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***Abstract**. This study examined the effect of adding metalloid is a type as a modifier on changes in the mechanical properties, microstructure, and wear mechanism of high-Mn steel. Several tests were carried out with different metalloid contents in the austenitized state. Microstructural changes were assessed using optical microscope and field emission scanning electron microscope (Fe–SEM) equipped with an energy-dispersive x-ray spectroscopy (EDX) detector. Analysis was carried out for changes in mechanical properties. Metalloid had a positive effect on the results of all mechanical tests, with particularly distinctive performance observed in the impact, tensile and friction tests. Industrial tests were carried out, the teeth of the mining excavator were cast from this steel composition and submitted for industrial testing. The readings of the shipped rock and the remaining length of the nose of the teeth served as indicators for assessing the efficiency. The final conclusion of the industrial tests was an increase in the productivity of excavator teeth made of modified steel high-Mn by more than 40% compared to standard teeth.*

***Keywords**: high manganese steel, modification, metalloid, mechanical properties.*

Introduction

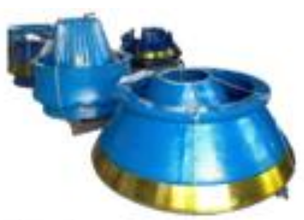
This research is aimed at developing an improved composition of cast austenitic steel (high-Mn) used for the manufacture of mining and processing production parts operating under conditions of increased impact loading and abrasive wear. The proposed steel contains carbon, silicon, manganese, phosphorus, sulfur, chromium and iron in the following ratio of components, wt. %: carbon 0.80÷1.0, silicon 0.30÷1.0, manganese 11.50÷14.0, sulfur no more than 0.050, phosphorus no more than 0.012, chromium no more than 1.0 the rest is iron.

Almalyk MMC JSC casts parts (spare parts) of crushers and excavators from manganese steel for more than 200 positions. A few of them are listed below:

For industrial testing, it was decided to cast the teeth of an experimental excavator from high-Mn steel with the addition of metalloid.

Methodology

Microstructural investigation was performed by an optical microscope (OM) model Olympus made in Japan, and a field emission scanning electron microscope (FE-SEM) model MIRA3TESCAN-XMU [1].



Crusher cone armors

Crusher bushings

Crusher jaw plates

Uniaxial tensile test, and Vickers microhardness test were completed to assess the effect of metalloid addition on the mechanical properties of the Mn-steel. Tensile test specimens were taken from a plate and prepared based on ASTM E8 standard. Charpy impact test samples were prepared by wire cut based on ASTM E23 standard with the dimensions of 10x10x55 mm. The Charpy impact test samples were in the form of CHARPY VNOTCH samples. All mechanical tests were repeated for three times and the average of these three tests is reported for each data point. Finally, to define the wear mechanism, the damaged wear surface of the samples was assessed by FE-SEM technique.

Results & Discussion

It can also be seen in Fig. 1 that addition of metalloid to the chemical composition of the high-Mn steel leads to larger austenite grain size, reduces the number of precipitates, and changes the location of the carbides from the grain boundaries to the grain interior.

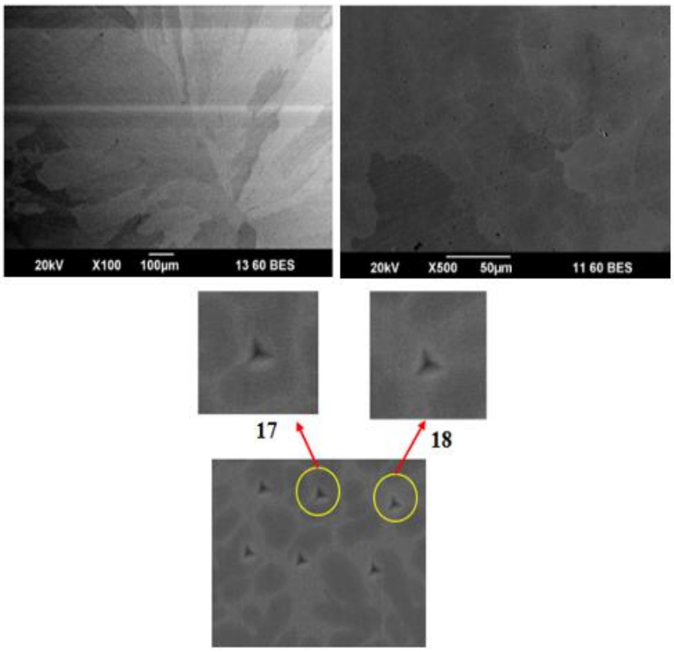


Fig. 1 - Results of optical microscopy of high-Mn steels containing all.

The EDX results are shown in Fig. 2. It is seen in this figure that in sample, austenite is the predominant phase. This is well matched with the microstructural observations of Fig.1. As well, in addition to austenite, the (Fe, Mn) xC complex carbide phase is also detected in the EDX analysis. This is well matched with the results of Azadi et al [2].

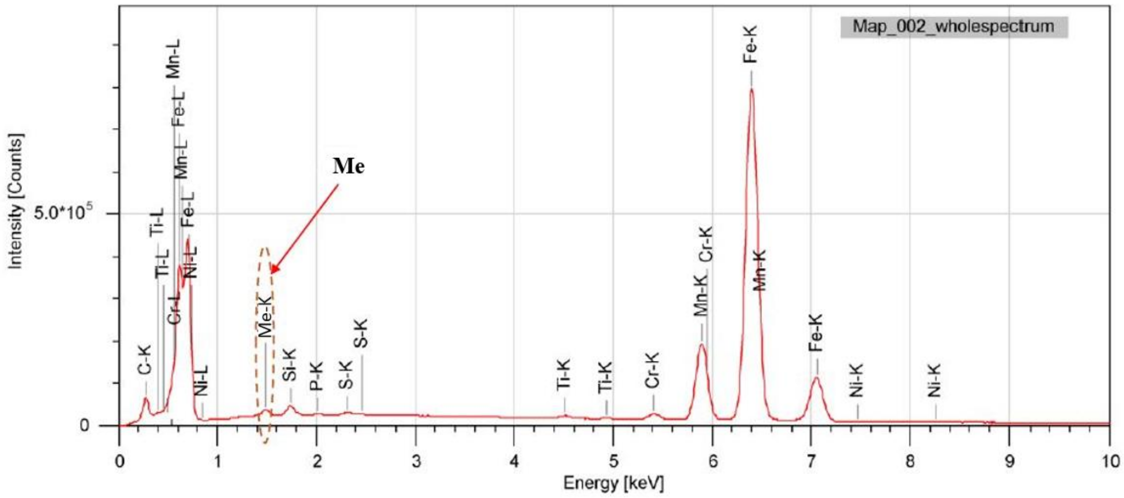


Fig. 2 - EDX pattern for the high-Mn steel containing of metalloid.

Samples were tested in the laboratory of Hyundai Motors, South Korea.

Steel high-Mn	**Strength, MPa**	**Plasticity, %**	**Hardness HB**	**Impact strength KCU**
GOST 977-88	360-380	34-42	186-220	260-350
With metalloid type modificated	620-635	24-28	290-375	390-460
Increasing parameters to an existing method:				
Changes in indicators	+70%	-32%	+63%	+41%

Table 1 - Mechanical performance test results

Adding of metalloid into the composition of Hadfield steels leads to a decrease in grain boundary carbides and a change in the morphology of carbides from continuous to discontinuous within the grains. It has been shown that the addition of metalloid to Hadfield steel increases the solubility of carbon in the austenite matrix and increases the size of the austenite grain itself [3]. It can be argued that the presence of metalloid in the composition of manganese steel stabilizes austenite relative to martensite. Sharply reducing grain size, down to the nanoscale, increases the wear resistance of these steels. In this sense, the coefficient of friction and weight loss are significantly reduced when the surface layers of the steel contain nano-sized grains [4].

In industrial tests, productivity gains of more than 40% were observed. The indicators are documented and approved by relevant acts.

Conclusions

High-Mn steel with the addition of metalloid has the following advantages:

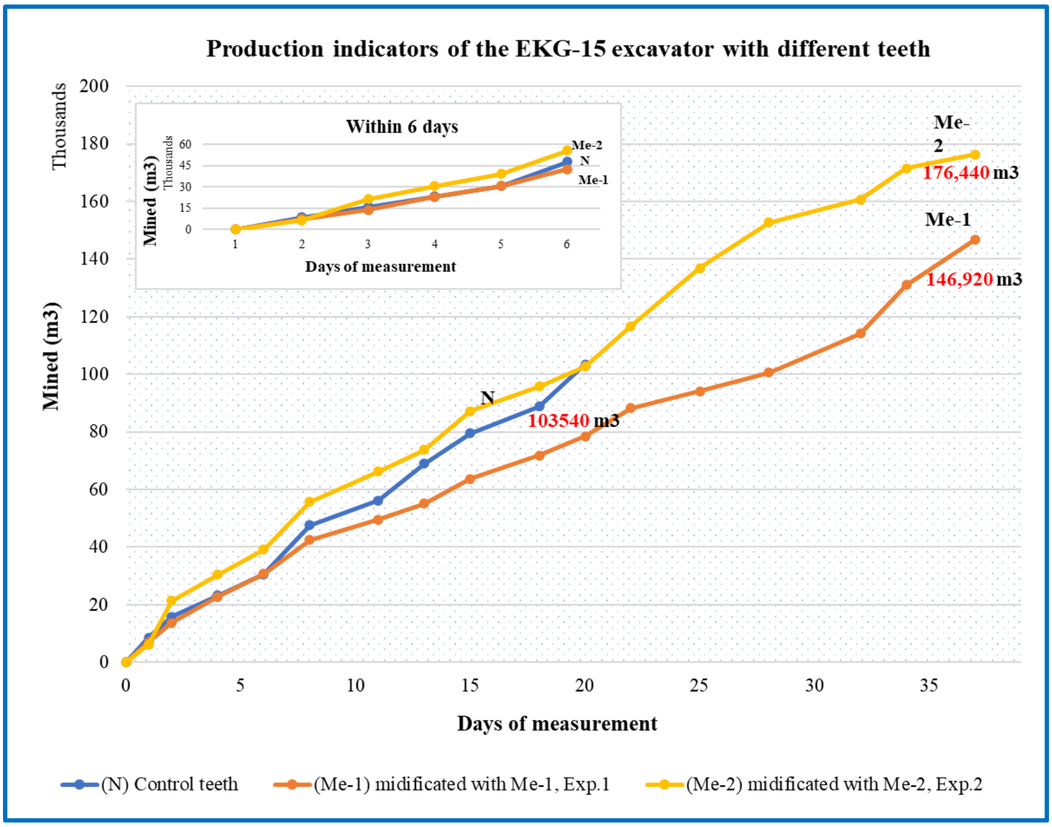
An increase in plastic characteristics due to the production of cleaner and thinner grain boundaries;

Mechanical properties are greatly improved;

As a result of the phase transition, a gamma-bar (γ’) was formed - an extremely strong crystal lattice;

The casting properties of the metal have increased, and this, in turn, has led to a decrease in porosity during the cooling process;

In industrial tests, teeth with the addition of metalloid increased productivity by more than 40%.



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