STUDY OF THE COMPOSITION AND PHYSICAL-MECHANICAL PROPERTIES OF A METAL COMPOSITE MATERIAL OBTAINED FROM SECONDARY METAL AND FERROALLOYS

S. Sh. Rahmonov
Assistant Lecturer, Department of Engineering Technology,
Kokand State University

Abstract. The article considers the formation of a metal composite composition based on secondary 110G13L steel, steel scrap and ferroalloys for industrial mill liners, as well as the assessment of its physical and mechanical properties. The study summarizes the results of XRF chemical analysis, metallographic observation, Brinell hardness measurement and contact friction-wear testing. According to the charge calculation, an alloy composition containing C 1.031%, Si 0.377%, Mn 14.316%, P 0.053%, S 0.016%, Cr 0.159% and Al 0.120% was brought close to the requirements for 110G13L steel. KSK modification had a positive effect on the microstructure and wear characteristics of the samples.

Abstract. The article examines the formation of a metal composite based on secondary 110G13L steel, steel scrap and ferroalloys for industrial mill liners. The results of XRF analysis, metallographic observation, Brinell hardness measurement and contact wear tests are summarized.

Annotation. The article studies the composition and physical-mechanical properties of a metal composite based on secondary 110G13L steel, steel scrap, and ferroalloys for industrial mill liners. XRF analysis, metallography, Brinell hardness, and contact wear tests were summarized.

Keywords: 110G13L, metal composite, ferroalloy, XRF analysis, KSK modification, Brinell hardness, wear.

Introduction

The material used for industrial mill liners must have high wear resistance, resistance to impact loads and the ability to form defect-free castings. In practice, high-manganese 110G13L steel is one of the important materials used for liners. However, the use of primary alloy increases production cost. Therefore, restoring the required composition on the basis of secondary 110G13L steel, steel scrap and ferroalloys is an urgent task. The purpose of this article is to scientifically analyze the composition, hardness and friction-wear indicators of a metal composite material obtained from secondary metal and ferroalloys.

Materials and Methods

A high-manganese metal composite alloy intended for industrial mill liners was selected as the research object. The charge included sorted steel scrap, secondary 110G13L steel, ferromanganese, ferrosilicon and Al-AB87 aluminium pieces. The chemical composition was determined using a PMA EXPLORER 5000 XRF analyzer. XRF analysis is a rapid method for determining the chemical composition of a sample based on X-ray fluorescence radiation. The samples were ground and polished, and their microstructure was observed with a metallographic microscope. Hardness was measured by the Brinell method using a Digital Universal Hardness Tester THBRV-187.5DX. Wear tests were carried out under contact friction conditions at different load values. The results were compared for a reference 110G13L sample and samples conventionally designated TSHTZ-1, TSHTZ-2, TSHTZ-3 and TSHTZ-4.

Table 1. Comparison of 110G13L steel and the calculated metal composite composition, %

Element	110G13L standard range	Calculated metal composite
C	0.9-1.5	1.031
Si	0.3-1.0	0.377
Mn	11.5-15.0	14.316
P	≤0.12	0.053
S	≤0.05	0.016
Cr	≤1.0	0.159
Ni	≤1.0	0.086
Al	—	0.120

Table 2. Charge components and their technological functions

Component	Amount per 1 ton, kg	Technological function
Sorted steel scrap (St3)	576.300	Main iron-bearing base and source of low-cost raw material
Secondary 110G13L	306.000	Provides the manganese-alloy base
Ferromanganese FMn95	71.400	Raises Mn content to the required level
Ferromanganese FMn78	61.200	Additional alloying and composition stabilization
Ferrosilicon FeSi65	3.060	Silicon alloying and assistance in deoxidation
Aluminium Al-AB87	2.754	Deoxidizing addition

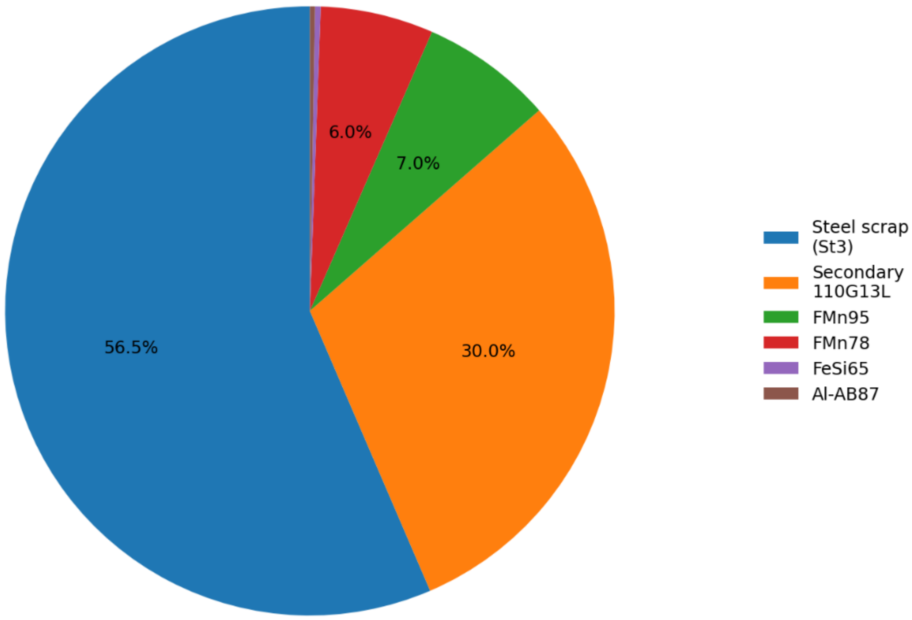

Figure 1. Mass distribution of the metal composite charge composition.

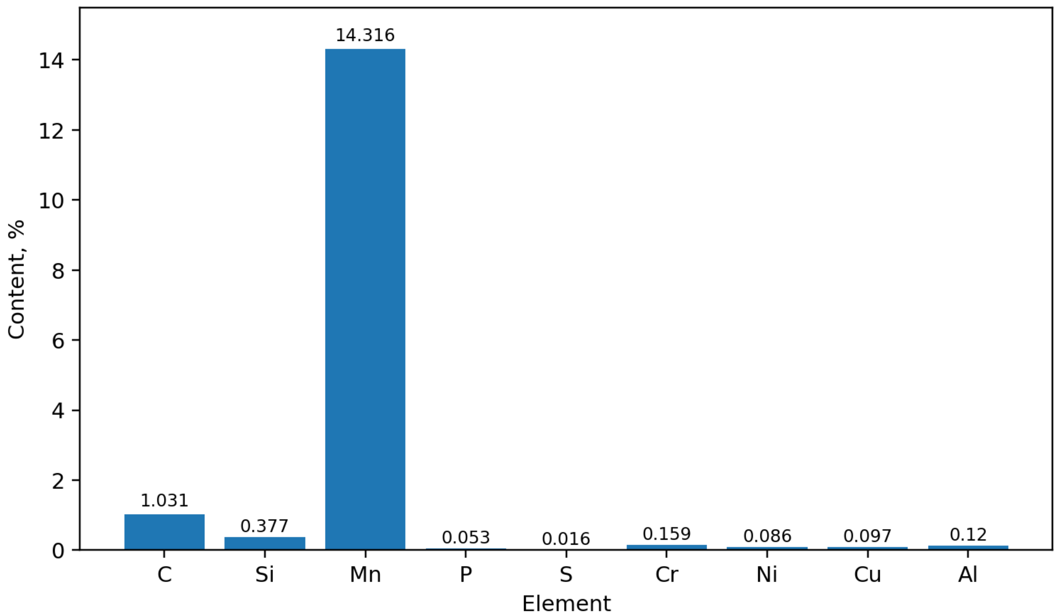

Figure 2. Main elements in the calculated metal composite composition.

Figures 1 and 2 show that steel scrap and secondary 110G13L steel constitute the main share of the charge, while ferroalloys serve to form the target chemical composition.

Results

As a result of the charge calculations, the metal composite composition was brought close to the standard ranges of 110G13L steel. In particular, a manganese content of about 14.316% provides the potential for work hardening and resistance to impact-abrasive conditions characteristic of high-manganese steel. The carbon content was 1.031%, which corresponds to the strength and structural stability requirements for high-manganese steels.

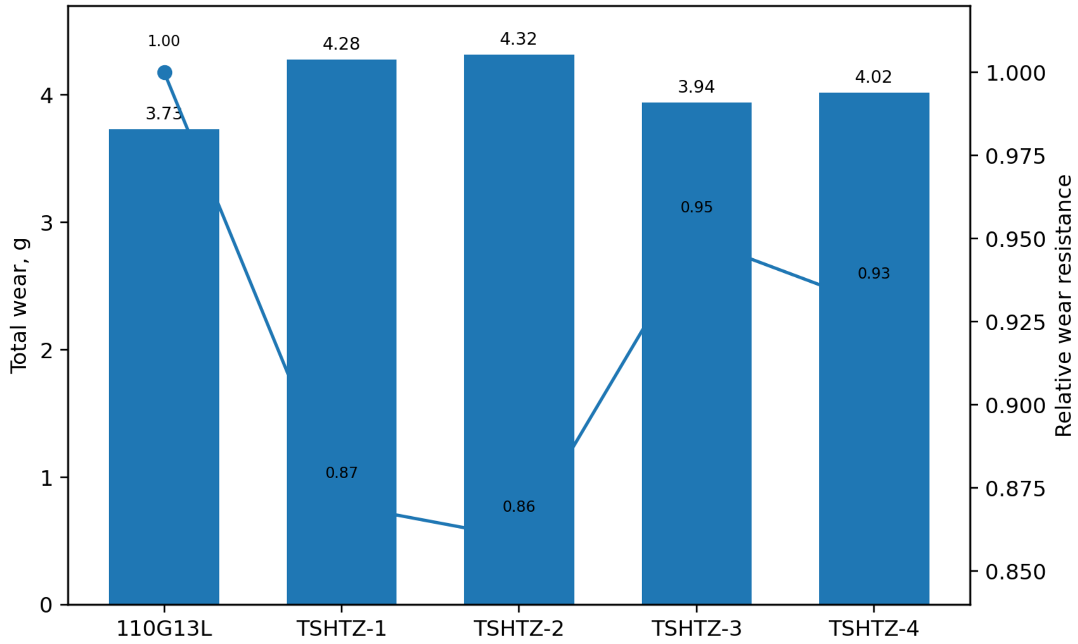

Figure 3. Results of contact wear tests of the samples.

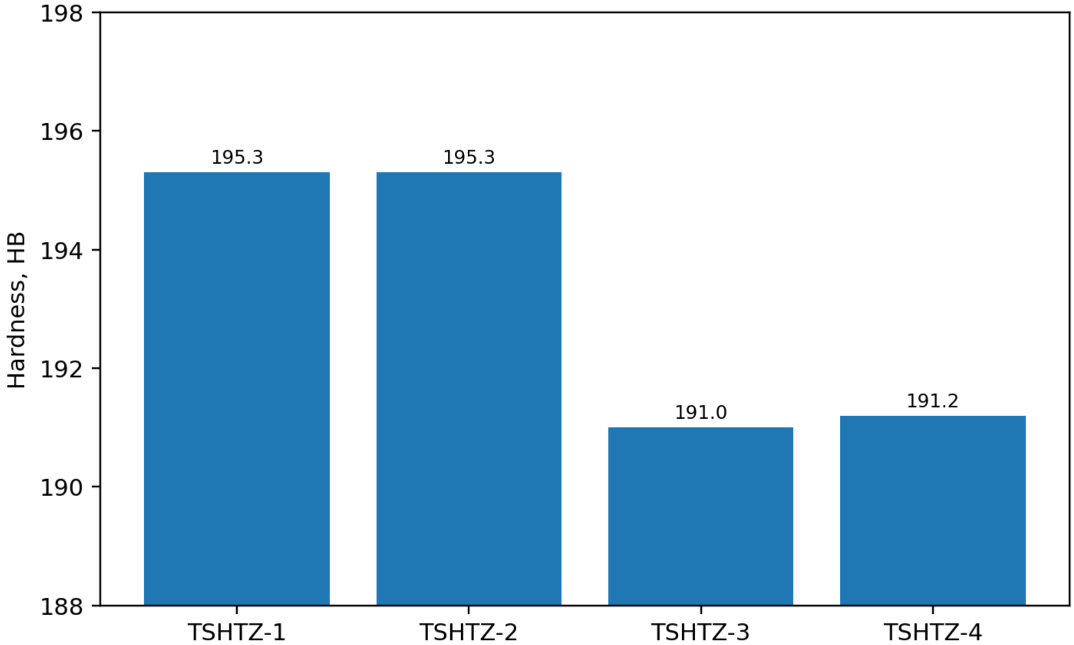

Figure 4. Average Brinell hardness of the samples.

According to Figure 3, the TSHTZ-3 sample shows a wear value closest to the reference 110G13L sample. Figure 4 shows that TSHTZ-1 and TSHTZ-2 have higher hardness values. The application of KSK, a calcium-strontium carbonate-based modifier, changed the shape of non-metallic inclusions located along grain boundaries in the microstructure and reduced the tendency to friction wear. This effect is also reflected in the contact wear test results.

Table 3. Contact friction-wear test results of the samples

Sample	0.5 kg	1.0 kg	1.5 kg	2.0 kg	2.5 kg	Total, g	Relative resistance
110G13L	0.54	0.61	0.72	0.91	0.95	3.73	1.00
TSHTZ-1	0.63	0.75	0.84	0.98	1.08	4.28	0.87
TSHTZ-2	0.65	0.73	0.87	0.96	1.11	4.32	0.86

TSHTZ-3	0.56	0.64	0.77	0.94	1.03	3.94	0.95
TSHTZ-4	0.59	0.65	0.76	0.97	1.05	4.02	0.93

Table 4. Brinell hardness results of the samples

Sample	1	2	3	4	5	Average HB
TSHTZ-1	194.4	194.9	194.7	196.1	196.3	195.3
TSHTZ-2	195.3	195.1	196.8	194.2	194.9	195.3
TSHTZ-3	190.8	191.3	191.8	190.3	191.0	191.0
TSHTZ-4	191.2	191.3	191.8	190.7	191.1	191.2

Discussion

In the wear tests, the reference 110G13L sample showed the highest relative resistance with a total wear of 3.73 g. The total wear of the TSHTZ-3 and TSHTZ-4 samples was 3.94 g and 4.02 g, respectively, which was better than the results for TSHTZ-1 and TSHTZ-2. This indicates that KSK modification and composition control in the samples obtained by the proposed technology had a positive effect on wear properties.

In terms of hardness, the TSHTZ-1 and TSHTZ-2 samples had an average value of 195.3 HB. Although the hardness of the TSHTZ-3 and TSHTZ-4 samples was somewhat lower, at approximately 191.0-191.2 HB, their better wear results demonstrate that not only hardness but also microstructure, the morphology of non-metallic inclusions and the distribution of alloying elements are important. Therefore, the optimum condition for a liner material is not the maximum hardness value, but a balance between hardness, impact resistance and structural homogeneity.

Conclusion

It was substantiated that a metal composite composition meeting the requirements of 110G13L can be obtained on the basis of secondary 110G13L steel, steel scrap and ferroalloys. The charge calculation resulted in an alloy containing C 1.031%, Mn 14.316% and Si 0.377%. KSK modification improved the morphology of non-metallic inclusions and stabilized friction-wear properties. The TSHTZ-3 and TSHTZ-4 samples demonstrated the effectiveness of the proposed technology and confirmed the possibility of using secondary metal composites in the production of industrial mill liners.

References

1. Vaisberg L.A., Baranov V.F., Bortnikov A.V. Main trends in the development of ore preparation at processing plants treating ferrous and non-ferrous metal ores.

2. Shishkin A.A., Yastrebov K.L. Study of the influence of friction force on the motion of charge elements in autogenous ore grinding mills. Vestnik IrGTU. Irkutsk: IrGTU Publishing House, 2012, No. 9 (68), pp. 211-213.

3. Yastrebov K.L., Druzhinina T.Ya., Karlina A.I. Autogenous ore grinding: concepts and methods. LAP LA, Saarbrucken, 2014, 41 p. UDC 622.732.

4. Yastrebov K.L., Druzhinina T.Ya., Shishkin A.A. Autogenous ore grinding: monograph. ISBN 978-5-8038-0881-7. Irkutsk, 2013, 346 p. UDC 622.732.

5. Shishkin A.A., Yastrebov K.L. Study of operating parameters of autogenous ore grinding mills. Vestnik IrGTU. Irkutsk: IrGTU Publishing House, 2012, No. 11 (70), pp. 176-180. UDC 622.734:622.76.