BG Pulse Journal USA
ISSN:1947-2536 http://www.bgpulseusa.com/index.php/bg
BG PULSE JOURNAL

EFFECT OF HEAT TREATMENT ON THE STRUCTURE AND PROPERTIES OF A BIMETAL

Ibrokhimov Boburjon
Kimyo International University in Tashkent
e-mail: Ibrohimov.2017@list.ru

Doi: https://doi.org/10.5281/zenodo.22950822

Annotation. Production of a cast iron-steel bimetal by casting and the use of heat treatment, namely quenching with subsequent tempering to improve its mechanical properties, primarily impact toughness.

Keywords: bimetal, impact toughness, hardness, microstructure, ferrite.

Introduction

The choice of casting method has a significant influence on the production of bimetallic materials. The main purpose of bimetallic casting is to combine two materials with different service properties [1], for example a wear-resistant working layer and a tougher supporting base. The durability and functional reliability of such castings depend primarily on a strong, continuous bond between the components.

In the sequential pouring process, the first metal is poured into the mold to form the base layer of the casting. The second metal is then poured into the same mold, forming the next layer. A key requirement for producing high-quality bimetallic castings is sound diffusion at the interface between the layers, which provides a strong metallurgical bond across the entire casting. To achieve this, the second metal is poured after a controlled time interval, so that the surface of the first layer has partially solidified but remains sufficiently hot and free of oxide films. During pouring of the second metal, it is essential to prevent oxides and oxide films from forming in the melt as it flows through the mold. Various technological measures can reduce or eliminate their formation.

For example, bimetallic castings have been produced from X8Cr13 steel and high-chromium cast iron [2]. The width of the diffusion zone at the interface ranged from 0.1 to 0.5 mm. Service tests showed that the life of bimetallic hammers was 1.4 times that of monolithic hammers.

Methods of research

The bimetal was produced from high-chromium white cast iron grade 280X29HJI and standard Ст3 steel bar using the horizontal sand casting method (Fig. 1). The molten steel was poured into receiving hopper 1 at a temperature of 1541°C. Once the required temperature was reached, a sodium tetraborate activator with boron oxide was added to the molten metal in receiving hopper 1 to prevent oxidation and ensure good bonding between the metals. The cast iron was then poured into receiving hopper 2 at a temperature of 1394°C. The interface temperature was measured using a pyrometer (Fig. 2).

BG Pulse Journal USA
ISSN:1947-2536 http://www.bgpulseusa.com/index.php/bg
BG PULSE JOURNAL

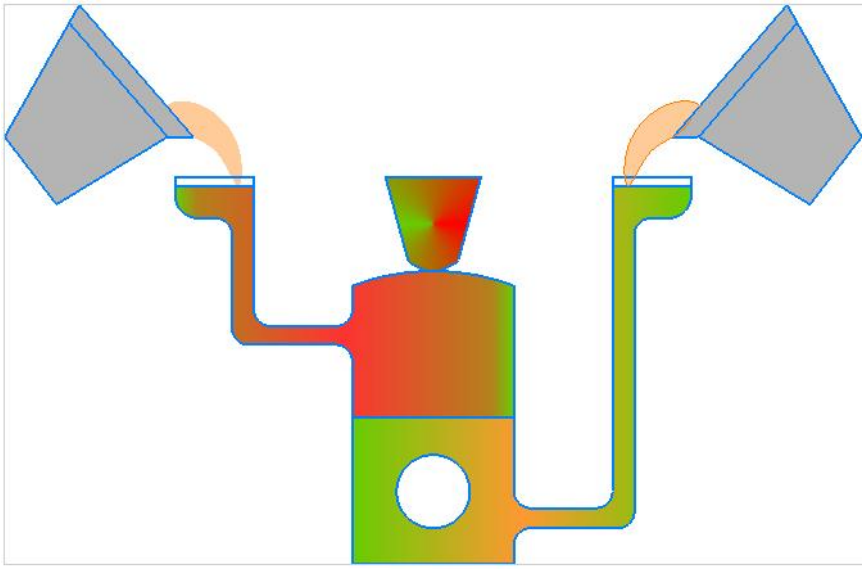


Fig.1. Metal casting process

The HRC hardness of the bimetal was measured on an HRS-150 hardness tester (Fig. 2) at no fewer than eight points in the steel, in the cast iron and at their interface, and the results were averaged. The chemical compositions of the cast iron and the steel, determined by spectral analysis, are given in Table 1. In addition to chromium carbides, the cast iron contained a small fraction of molybdenum carbides [3]. The impact toughness before and after heat treatment was determined by the Charpy method in accordance with GOST 9454-78 [4], with five specimens tested for each condition.







Fig.2. Infrared pyrometer (-50 to 1,600 °C), HRS-150 Hardness Tester, and WDW–20H Copper Tester

Table 1

Chemical composition of the alloy

Alloys	Elements, %

	C	Si	Mn	P	S	Cr	Ni	Mo	Ti	Cu
280Х29НЛ	2,82	0,51	0,57	0,06	0,03	28,8	1,54	0,05	–	0,2
Ст3	0,16	0,1	0,5	0,03	0,04	0,2	0,1	–	–	0,16

Results of experiment

The bimetal under study is intended for the manufacture of working tools for grinding hard materials. It must therefore combine high strength with adequate wear resistance and impact resistance.

Table 2 presents the Rockwell hardness of the bimetal components before and after heat treatment.

The most homogeneous joint structure was obtained after quenching and tempering (Fig. 3). Fig. 4 shows the bimetal impact specimens notched on the steel side and on the cast iron side. The results of the impact tests are given in Table 3. The fracture surfaces (Fig. 5) show brittle fracture on the high-chromium cast iron side and ductile fracture on the structural steel side.

After heat treatment, both the hardness and the impact toughness of the bimetal increase. This is presumably due to the more uniform distribution of carbides near the interface between the components.

Table 2

Rockwell hardness of the bimetallic alloy

Stages	Steel	Cast iron
Base alloy	35-38 HRC	45-46 HRC
After heat treatment	49-51 HRC	53-56 HRC

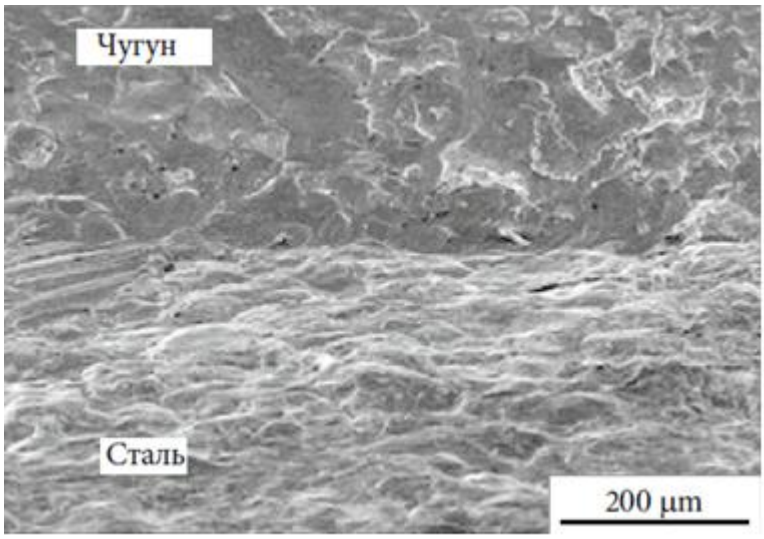


Fig.3. Structure of a bimetallic alloy after heat treatment

Table 3

Impact toughness of the bimetal before and after heat treatment

	Notch location	Fracture mode	Impact toughness KCU (J/sm^2)
As-cast	Steel side	Brittle	41
	Cast iron side	Brittle	35
Heat treated	Steel side	Ductile	53
	Cast iron side	Ductile	45



Fig.4. Samples for impact test

Conclusion

1. Sequential casting of low-alloy steel and high-chromium cast iron into a sand mold resulted in a flawless bimetal with good cohesion at the phase boundary and a uniform microstructure.
2. After diffusion annealing and low-temperature tempering, the microstructure of the “steel-cast iron” bimetal becomes more uniform, while the hardness and impact toughness of its components increase simultaneously.

References

1. Production technology of bimetallic and multilayer castings cast by gravity and centrifugal casting processes. Patent CN102917816A
2. M. Chelewa, T. Wrobel, and S. Tenerowicz, “Bimetallic layer castings,” J. Achiev. Mater. Manuf. Eng., 43(1), 385 – 392 (2010).
3. Ахмедов Х.И., Барановский К.Э., Улугов Г.Д., Жумаев А.А. Сравнительное исследование структуры отливок из белых износостойких чугунов // ГОРНЫЙ ВЕСТНИК Узбекистана №3 (90) Июль-Сентябрь 2022, 56 стр.

4. МЕЖГОСУДАРСТВЕННЫЙ СТАНДАРТ. Метод испытания на ударный изгиб при пониженных, комнатной и повышенных температурах. https://files.stroyinf.ru/Data2/1/4294848/4294848714.htm
5. Ibrokhimov, B., Tursunbaev, S. (2025). "Low-Temperature Treatment of Malleable Cast Iron." American Journal of Applied Science and Technology, Vol. 05, Issue 07, pp. 8–11. DOI: 10.37547/ajast/Volume05Issue07-02.
6. Tursunbayev, S., Turakhodjayev, N., Mardanokulov, S., Zokirov, R., & Odilov, F. (2023). The effect of lithium on the mechanical properties of alloys in the Al-Li system. In E3S Web of Conferences (Vol. 390, p. 05046). EDP Sciences.
7. Tursunbaev, S., Turakhodjayev, N., Mardanokulov, S., & Tashbulatov, S. (2023). Influence of germanium oxide on the mechanical properties of aluminum alloy. Eurasian Journal of Engineering and Technology, 16, 91-94.
8. Saidmakhamadov, N., Turakhodjaev, N., Tursunbaev, S., Zokirov, R., Tadjiev, N., Abdullaev, K., ... & Juraev, J. (2024). Improving the design of the lining of the ball mill used to improve the quality of grinding. In E3S Web of Conferences (Vol. 525, p. 02017). EDP Sciences.