THE RECYCLING OF METAL WASTE PRODUCTION
MONOCRYSTAL OF PERMANENT MAGNETS

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Abstract

Investigate the potential use of the metal waste own production in the manufacture of mono-crystalline permanent magnets alloy UNDKT5AA. It is known that the repeated use of the waste in the alloy accumulate harmful impurities (carbon, sulfur, nitrogen) and magnetic properties of permanent magnets are reduced [1-3]. To prevent this phenomenon applied additional preparatory clean source of charge materials, as well as changed the technology of melting and casting alloy UNDKT5AA. Formed at the metal waste has reduced content of impurities. Using such wastes as a component of the charge, were made of mono-crystalline permanent magnets. Modes of cultivation and heat treatment of the magnets were standard. The chemical compositions of the alloy magnets match the specified value. The number of harmful impurities in the alloy was in permissible limits. Magnetic properties of magnets to meet the requirements of existing standards [4]. Thus the cost price of manufacture of mono-crystalline permanent magnets has decreased more than on 30%.

Keywords: mono-crystalline magnets, metal wastes, pollutants, recycling, and magnetic properties, cost of sales.

1. INTRODUCTION

At the present time mono-crystalline permanent magnets on the basis of the material UNDKT5AA are the core element of many of electrical machines and devices in the systems of navigation and control of aviation and space technology. For production of single crystals with a perfect crystal structure as the components of the batch used materials of high purity, because the impurities, contained in these materials, lead to a change in the nature of crystallization of the alloy, the formation of new centres of crystallization and, ultimately, to a decrease in the magnetic properties of permanent magnets [1,3,5]. In connection with this the Prime cost of the production of mono-crystalline of permanent magnets is very high. The aim of this work is to study the possibility of the use of metal waste own production instead of net charge materials in the manufacture of mono-crystalline permanent magnets alloy UNDKT5AA and reduction of the cost of these magnets.

2. EXPERIMENTAL RESULTS AND DISCUSSION

For the manufacture of mono-crystalline permanent magnets as a charge materials used pure metals of the following brands: cobalt Co-0 GOST 123-98, Nickel Ni-0 GOST 849-97, copper M-0 GOST 859-2001, aluminum Al99 GOST 11069-2001, titanium high cleaning ТУ48-4-282-73, iron carbonyl refined ЧМТУ-1-884-70. For the introduction of sulfur in the alloy used synthetic ligature of the iron-sulfur. To melt the alloy and produce billets with a polycrystalline structure used vacuum induction furnace WIS-0,016. The process of melting and pouring of molten into a mold conducted in an atmosphere of purified argon. Mono-crystalline work piece received cultivation in fireproof containers of pure aluminum oxide with the help of high-frequency vacuum unit with induction heating «Mould-203» at the speed of movement of the heat node of 0.2-0.5 mm/min.
The content of sulphur and carbon in metals and alloys determined with the help of Express - analyzers al-7932, an-7529 and ELTRA CS-800 (Germany). Control of magnetic parameters of produced with the help of the PERMAGRAPH-300 (Germany).

At the first stage of the research analyzed the actual content of impurities, carbon in the source of charge materials used in the manufacture of permanent magnets. The results of the research are given in table 1.

Tab. 1 The carbon content of the initial charge materials

<table>
<thead>
<tr>
<th>The name and mark of the material</th>
<th>Carbonyl iron</th>
<th>Cobalt</th>
<th>Nickel</th>
<th>Copper</th>
<th>Aluminium</th>
<th>Titan high cleaning</th>
<th>the Ligature of the iron-sulfur</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon content, % of mass.</td>
<td>0,04</td>
<td>0,05</td>
<td>0,008</td>
<td>0,02</td>
<td>0,02</td>
<td>0,008</td>
<td>0,424</td>
</tr>
</tbody>
</table>

As can be seen from table 1, the largest amount of carbon containing carbonyl iron, cobalt, and the ligature of the iron-sulfur. A significant amount of carbon contained also in aluminium and copper. It should be noted that the content of carbon in these materials more than indicated in the certificates of the manufacturer.

To reduce the carbon content in carbonyl iron and cobalt was held additional remelting of these materials in a vacuum induction furnace with the addition of Fe₂O₃, taken as a solid oxidizer in the amount necessary to complete binding present in the melt of carbon. In result it was possible to reduce the carbon content of these metals in almost 4 times (table 2).

Tab. 2 The content of impurities, carbon in the materials after remelting together with solid oxidizer

<table>
<thead>
<tr>
<th>Material</th>
<th>The content, % of mass.</th>
<th>To remelting</th>
<th>After remelting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbonyl iron</td>
<td></td>
<td>0,04</td>
<td>0,01</td>
</tr>
<tr>
<td>Cobalt grades K-0</td>
<td></td>
<td>0,05</td>
<td>0,013</td>
</tr>
</tbody>
</table>

As can be seen from table 2, refining of carbonyl iron and cobalt with solid oxidizer (in this case with Fe₂O₃) is an effective method of cleaning from impurities of carbon.

Along with scrap materials was identified additional source of pollution magnetic alloy carbon. It was the material of receiving-and-filling the Cup. To eliminate direct contact of the melt with the material of the Cup in
her inner part were installed protective inserts made of pure aluminum oxide, made by the method of plasma spraying.

In table 3 presents data on the carbon content in magneto-solid alloy UNDKT5AA in various versions of the technology of smelting alloy and execution of the drilling of the Cup.

**Tab. 3** The carbon content in the alloy UNDKT5AA after the operation of melting and casting into a mold.

<table>
<thead>
<tr>
<th>Versions of the technology of steel alloy and execution of the drilling of the Cup</th>
<th>The content in the alloy, % of mass.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Melting alloy without additives Fe₂O₃, casting melt without the use of inserts of Al₂O₃</td>
<td>0,041</td>
</tr>
<tr>
<td>2. Steel alloy with the addition of Fe₂O₃, casting melt without the use of inserts of Al₂O₃</td>
<td>0,012</td>
</tr>
<tr>
<td>3. Steel alloy with the addition of Fe₂O₃, casting melt with the use of inserts of Al₂O₃</td>
<td>0,006</td>
</tr>
</tbody>
</table>

Low-carbon metal waste magneto-solid alloy UNDKT5AA formed after melting of advanced technology (option 3), were used as components of the mix material in the manufacture of mono-crystalline permanent magnets. Net charge materials in this 30%, 50% and 100% have been replaced by low-carbon waste. In all cases, the technological regimes of growing single crystals of thus obtained alloys, as well as the modes of their thermo-magnetic and mechanical processing, were the same.

Measurements of the magnetic properties of single crystals of permanent magnets have shown, that replacement of up to 50% of net charge materials for own production waste does not lead to a decrease in the magnetic properties. With the further increase in the content of waste in charge magnetic properties of magnets are slightly reduced, but still remain within the requirements of Russian standards. Thus the cost price of production of single crystals of permanent magnets reduced by about 30%. For finding-out of the reasons of reduction in magnetic properties, which occurs when using the waste in a quantity of more than 50%, further experiments.

3. **CONCLUSIONS**

The use of solid oxidizers in smelting magnetical alloy UNDKT5AA and protective plasma-sprayed inserts of pure aluminum oxide by the filling of the mold allows you to significantly reduce the carbon content in the alloy, which gives the opportunity to use the net the charge components up to 50% (by weight) of their own metal production waste, without reducing the level of magnetic properties of single crystals of permanent magnets and approximately 30% lower the cost of production of these magnets.
LITERATURE


