Increasing the Service Lifetime of a Working Elements of Mixer-Pneumosuperchargers for the Building Mixtures Preparation

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Abstract. Comparative studies of the blade’s materials for mixer-pneumosuperchargers operated under abrasive conditions were carried out. For this purpose in the production environment at the construction site the service lifetime of the blades offered by various manufacturers was measured on four “SO–241” mixer-pneumosuperchargers. Production of building mixture in quantity declared by the manufacturer was used as a control period. It is shown that blades made of 110G13L steel retained their service properties almost until the completion of the control period. Also, the composition and technology for producing the working elements of mixer-pneumosuperchargers from wear-resistant white cast iron alloyed with chromium and manganese was developed. The test results showed that the blades made of the proposed material exceeded the service lifetime of the blades made of 110G13L steel.

1. Introduction

Currently, the wear problem of consumables for mixer-pneumosuperchargers become quite urgent due to the lack of centralized supplies and the presence of uncontrolled suppliers on the Russian market of metal products.

The principle of mixer operation is mixing of building mixture (semi-dry mortar), which includes: cement, sand, water, chopped basalt thread and supplying the finished mixture to the place of laying. The mixing element is the blades operating under abrasive conditions. Alloys such as cast iron and wear-resistant steel alloys are used as material for blades. The technology for producing blades is also different – this is either using of rolled metal or casting. In recent years, the leader in the production of sheet metal blades was the Swedish wear-resistant Hardox 450 steel with a hardness of 450 HB and designed to meet special demands on wear resistance [1–6]. The foundry technology of manufacturing the working elements is characterized by the use of various alloys based on iron, starting from steel 15, reinforced by depositing, to high-carbon alloys, such as cast irons [7–16]. However, according to consumers, the blades often do not withstand the declared service lifetime. Therefore, the task was to obtain the blades for mixer-pneumosuperchargers with a high and guaranteed service lifetime.

In this regard, comparative studies of the service lifetime of the working elements of mixer-pneumosuperchargers from various materials were carried out along with the selection of the
optimal material, considering the price-quality ratio, and technology development for producing blades with stable operational properties.

2. Results and discussion
To compare the service lifetime of the working elements of mixer-pneumosuperchargers at production conditions with the service lifetime declared by the suppliers, the blades made of the most commonly used materials (SCh 25 cast iron, steel 15 reinforced with H10 steel, 110G13L steel and Swedish wear-resistant Hardox 450 steel) were selected. Each set of four blades from the selected materials was installed in the “SO–241” mixer-pneumosuperchargers: two blades ensure the movement of the mixture components to the center and two blades for axial movement of the components in the opposite direction (figure 1). The experiment involved four mixer-pneumosuperchargers.

![Solution mixing blades: a – for moving components of mixture to the center, b – for axial movement of components in the opposite direction.](image)

Figure 1. Solution mixing blades: a – for moving components of mixture to the center, b – for axial movement of components in the opposite direction.

The amount of semi-dry mortar (cement, sand and water in cubic meters) produced by the mixer-pneumosuperchargers was measured until the failure of mixing blades or reaching the declared service lifetime (figure 2).

![Declared and produced amount of mixture before blades failure, m³](image)

Figure 2. The results of a comparative study conducted at production conditions. *The values of the produced amount of the mixture were rounded to hundreds.
Figure 2 shows that by blades made of gray cast iron was produced 58.7% less mixture before replacement, due to intensive wear of working surfaces than was declared by the suppliers, for Hardox 450 steel reduction was 20.4% and for 15 steel reinforced with X10 steel reduction was 41%. Blades made of 110G13L steel retained their service properties almost until the completion of the control period. However, given the high cost and certain technological difficulties of the production of castings from 110G13L steel a composition of white cast iron alloyed with chromium and manganese was developed by request of a construction organizations using mixer-pneumosuperchargers and showed results for wear resistance tests comparable to 110G13L steel at an affordable price [17, 18]. At the same time, the task was set to increase the service lifetime of such blades. Alloyling with chromium and manganese was chosen, since they inhibit the graphitization process, which is guarantees production of white cast iron with high hardness. According to the sizes of the two blades, different in configuration, provided by the construction organization, wooden patterns with a thickness of 10 mm, pattern allowances and two holes with a diameter of 10 mm were made (Figure 3).

![Figure 3. Patterns of the mixer-pneumosuperchargers blade.](image)

To obtain holes in the castings, rods made of a mixture on an organic binder material with good knockability and providing the necessary surface cleanliness were used [19, 20]. The composition of the rod’s mixture is presented in table 1.

| Component                           | Weight fraction, % |
|-------------------------------------|--------------------|
| Sand brand 2K₂O₂02                  | 95                 |
| Technical lignosulfonates           | 3                  |
| Mustard filter cake                 | 2                  |

The rods were dried in an “EKPS–10” resistance furnace at 240–260 °C for 30 minutes. For molding a sand-clay mixture was used. The composition of the charge included purchased steel scrap (GOST 2787–78), cast iron (GOST 4832–95), ferrochrome (GOST 4757–91) and ferromanganese (GOST 4755–91). The charge was melted in the “IST–0,06” induction furnace. Low tempering was carried out to relieve internal stresses of castings. For heat treatment of castings, the “SNOL 80/12” electric furnace was used. Simultaneously with the molding and filling of the blades, additional samples were made to determine the chemical composition, conduct metallographic studies and determine the mechanical properties of the obtained castings. The chemical composition of the obtained castings is presented in table 2.
Table 2. The chemical composition of white cast iron (wt. %).

| C   | Mn | Si  | Cr  | Ni  | S   | P   | Fe  |
|-----|----|-----|-----|-----|-----|-----|-----|
| 2.53| 2.09 | 1.36 | 5.15 | 0.093 | 0.030 | 0.0050 | rest |

To carry out metallographic studies, metallographic sample were made from a metal of additional sample. The presence and shape of graphite in cast iron was assessed. To study the microstructure, etching was performed with a 4% solution of nitric acid in ethanol. The microstructures of samples of white cast iron are presented in Figure 3.

![Figure 3. Microstructures of white cast iron samples: a – without etching; b – with etching.](image)

As can be seen from Figure 4, alloying of cast iron with manganese leads to inhibiting the release of graphite, perlite grain refining and cast iron bleaching. The introduction of chromium increased the strength and hardness of castings and inhibited carbon graphitization process. The ratio of carbon, manganese and chromium obtained in the composition of cast iron when interacting with sulfur neutralized its harmful effect. Minor amount of fine graphite inclusions had a flaky shape (Figure 4a). Figure 4b shows that the microstructure of cast iron consists of perlite and ledeburite. The hardness of the test cast iron was 470 HB, which exceeds the hardness of Hardox 450 steel.

The experimented batch of alloyed white cast iron was manufactured and tested under production conditions. The test results showed that the blades made of the proposed material failed only after the production of 43,000 m³ of the building mixture, which exceeded the service lifetime of the blades made of 110G13L steel.

3. Summary

As a result of the work, the following results were obtained:
- the composition of white cast iron was developed for the manufacture of working elements of mixer-pneumosuperchargers;
- An experimental technology was developed for the production of working elements of mixers-pneumosuperchargers by casting in sand-clay molds;
- the service lifetime of the blades was significantly increased, which made it possible to recommend the proposed cast iron composition and technology for producing castings for the manufacture of working elements of mixer-pneumosuperchargers.

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