Changes in the Hardness of Aluminum Alloys in the Influence of Lithium

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ABSTRACT

In the manufacture of cast parts from aluminum alloys, the hardness of the alloy is important. The article examines the change in their hardness by the Rockwell method when using lithium-fluorine containing compounds from aluminum alloys of grades AK7 and D16 as a flux. The research was carried out in the laboratory of "Foundry technologies" Tashkent State Technical University. Based on the results of the study, the authors draw their conclusions set out in the article.

Keywords: hardness, Rockwell, temperature, aluminum, lithium, resistance furnace, part, flux.

Introduction

In order for parts and mechanisms to work for a long time and reliably, the material from which they are made must meet the necessary operating conditions. Therefore, it is important to control the permissible values of their basic mechanical properties. Aluminum alloys with other metals and nonmetals (copper, manganese, magnesium, silicon, iron, nickel, titanberyllium, etc.) are widely used as structural materials. In aluminum alloys, along with the good properties of pure aluminum, high strength properties of alloying compounds are embodied. For example, iron, nickel, titanium increase the fire resistance of aluminum alloys. Provides hardening heat treatment of copper, manganese, magnesium, aluminum alloys. As a result of soldering and heat treatment, the strength of aluminum alloys increases from σ_v 100 to 500 MPa, and hardness-from HRA 20 to 150.

Methods

The Rockwell method was used to measure the hardness of samples. When using this method, the trace of the object immersed in the sample is measured during the immersion process itself, which greatly speeds up and facilitates testing. Depending on the hardness of the test material, the body (triplet) immersed in the sample can be of two types. When testing samples with low and medium hardness at a load of 100 kg (scale b), a steel ball with a diameter of 1.59 mm is used, and samples with high hardness at a load of 150 kg (scale C) or at a load of 60 kg (scale a) - a diamond cone with an angle at the end of 120 ° and a radius of the tip of 0.2 mm. A grid (S scale) was used as a sample, since refractory white cast iron was used. The above loads include both the main load and the initial load. The load on the test sample is reflected in two consecutive stages. To eliminate minor defects on the sample surface, the specific load (initial load) at the first stage was 10 kg, at the second stage the specific load (mainly load) was 90 kg when it was a steel ball, and 140 kg when it was a diamond cone. Situations of a triple (steel sphere or cone) During the test, the samples are shown in Figure 1.

The hardness of the sample is characterized by subtracting the depth of the trace (H2) formed when exposed to the sample of the primary load, and the depth of the trace (H1) formed when exposed to the initial load. Measured in three schools by the Rockwell method. Whichever scale is used when testing a part or sample, a mark of the same scale is placed to the right of the HR label, for example: HRC, HRB, HRA.

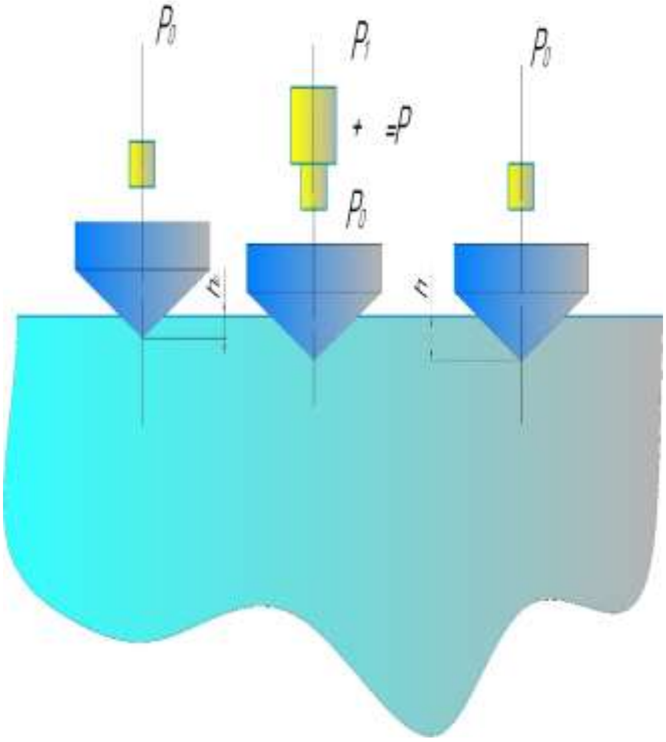

Figure 1. Triad situations in determining hardness.

The method of determining the hardness of a sample and parts using a Rockwell press is widely used, since this method allows testing both soft and very hard materials. In addition, the trace left on the part during the test is very small, which does not impair the quality of the part. Another advantage of this method is that the testing time does not exceed 30 – 60 seconds. The HRA scale was used in the experiments. A Rockwell ZIP TK-2M press was used to measure hardness (Fig. 2).

Figure 2. ZIP TK-2M Rockwell Press.

Experiments

The experiments were carried out on aluminum alloys of grades AK7 and D16. The weight of the charge for the samples was 80 grams. The samples were diluted in a resistance furnace and poured into sand-clay molds. The alloys were liquefied when the resistance furnace was set to a temperature of 750°C. As separate alloying elements, a fluorine compound with lithium and pure lithium were introduced into the charges. At the same time, a fluorine compound with lithium in the amount of 5%, 10%, 15% and was added to the total mass of the charge.

Figure 3. Samples extracted from ingots.

Pure lithium metal was added to a separate sample in an amount of 1% of the total mass. Since the pure metal lithium was a highly alkaline metal, when more than 2% was added during the liquefaction process, a small explosion was formed, which caused damage to the crucible. Samples with a diameter of 30 mm and a thickness of 5 mm were cut out of the obtained samples on a lathe (Fig.3). The detached samples were treated with an abrasive and the measured surface was leveled (Fig.4). The flattened samples were measured on a Rockwell press 3 times per sample in sequence.

Figure 4. Polished samples.

Results

The results of sample measurement are presented in the table 1 below. Based on the results obtained, a link chart was developed (Figure 5 and Figure 6).

Table 1

The results of sample measurement

№	Samples	HRA-1	HRA-2	HRA-3	$HRA_{average}$
1	AK7	18	20	17	18.3
2	AK7+1% lithium	15	14	20	16.3
3	AK7+5% lithium fluoride	19	16	22	19
4	AK7+10% lithium fluoride	19	18	22	19.6
5	AK7+15% lithium fluoride	18	19	18	18.3
6	D16	19	21	20	20
7	D16+1% lithium	17	18	15	16.7
8	D16+5% lithium fluoride	24	26	25	25
9	D16+10% lithium fluoride	24	28	26	26
10	D16+15% lithium fluoride	28	27	25	21.6

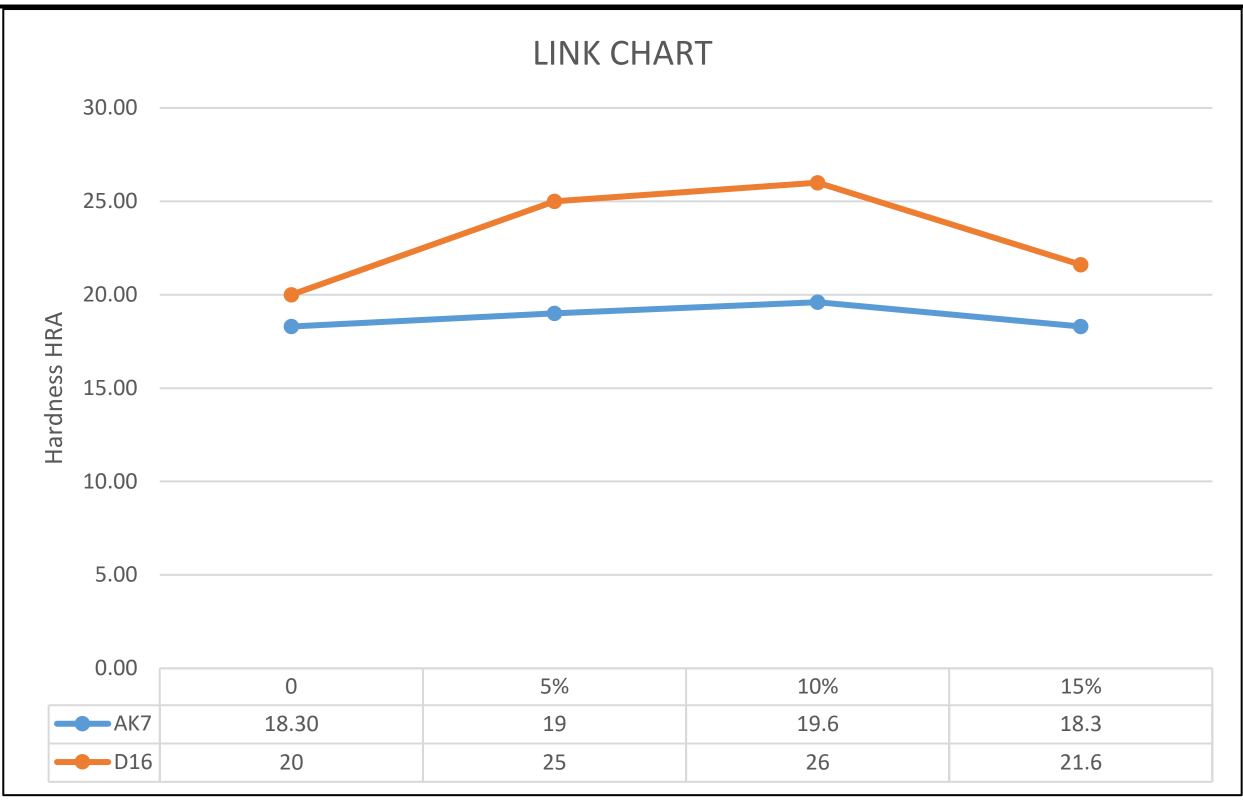

Figure 5. Link chart.

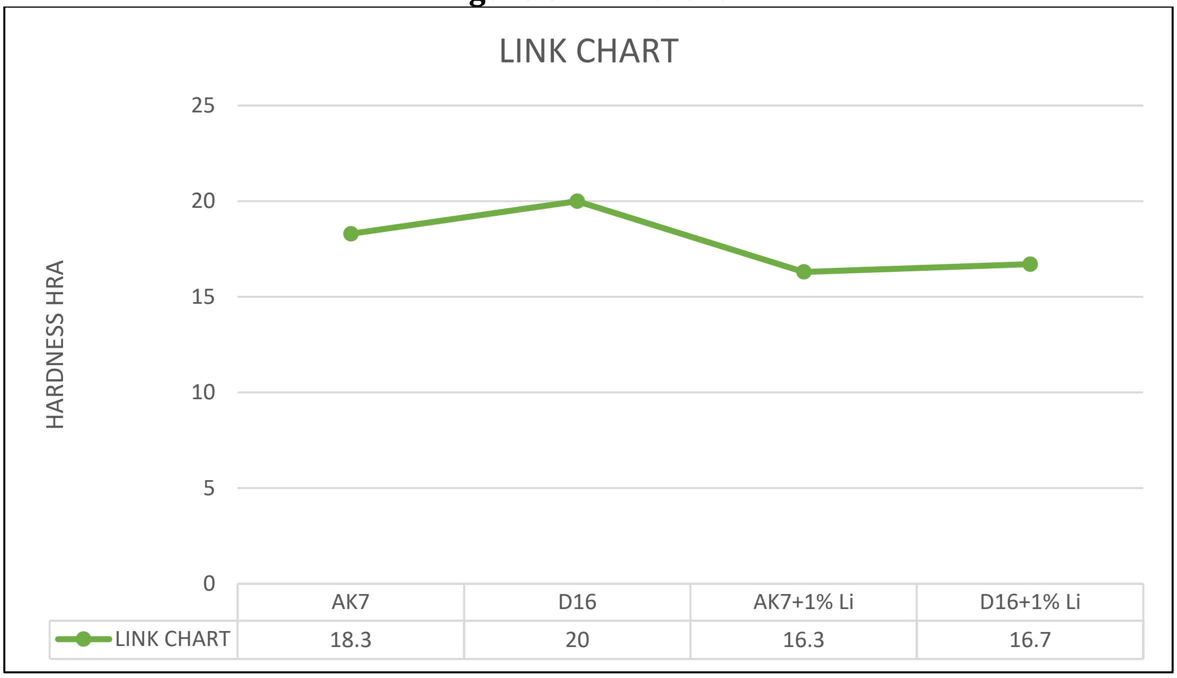

Figure 6. Link chart.

Conclusions

Experiments based on the use of aluminum alloys as alloying elements have shown that the use of pure lithium as an alloying element in open conditions did not give good results. When lithium metal was introduced into aluminum alloys of grades AK7 and D16 in the amount of 1% of the charge weight, the hardness of the alloys decreased within 9% - 16.5%. When using a lithium-fluorine-containing compound as a flux, the hardness compared to aluminum alloys without the addition of a lithium-fluorine-containing compound increased to 3.8-7.1% for the AK7 alloy and to 8-27% for the D16 alloy. An effective result was achieved by adding a lithium fluoride compound in an amount of 10%. The hardness began to decrease with the addition of an amount of 15%. When diluting an aluminum alloy, a lithium-fluorine-containing compound is recommended to be added in an amount of 10% of the mass fraction of the charge.

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