The effect of lithium on the mechanical properties of alloys in the Al-Li system

Sarvar Tursunbayev[1*], *Nodir* Turakhodjayev[1], *Sharofuddin* Mardanokulov[1,2], *Ruslan* Zokirov[3], and *Furkat* Odilov[4]

[1]Tashkent State Technical University, Tashkent, Uzbekistan
[2]Harbin Engineering University, Harbin, P.R. China
[3]Branch of the D.I.Mendeleev Russian University of Chemical Technology in Tashkent, Tashkent, Uzbekistan
[4]Academy of the Ministry of Internal Affairs, Tashkent, Uzbekistan

Abstract. The article considers the dependence of wear resistance and hardness on each other on the mechanical properties of alloys in the aluminum-lithium system. In experiments, lithium fluorine compound from A K7 and D16 aluminum alloys was added as alloying elements to obtain an aluminum-lithium sample. Based on the mechanical properties of the samples, the hardness was changed in accordance with the Rockwell method and the abrasiveness was investigated.The samples were poured into a heat-resistant furnace at a temperature of 750 °C.The lithium fluoride compound was introduced into the charge in three different masses. Lithium compound with fluorine was added in an amount of 5%, 10% and up to 15% of the total weight of the charge. Based on the conducted experiments, a graph of the dependence of the hardness of the samples and the wear resistance was compiled.

1 Introduction

Aluminum is chemically active reliably protects the metal from further oxidation. But if aluminum powder or aluminum foil is strongly heated, the metal burns with a blinding flame, turning into aluminum oxide. Aluminum dissolves even in dilute hydrochloric and sulfuric acids, especially when heated. But aluminum does not dissolve in highly diluted and concentrated cold nitric acid [1]. The addition of rare metals to aluminum alloys increases their durability, heat resistance, corrosion resistance. Many studies have been conducted on the mechanical properties of aluminum-lithium alloys. In the research paper "Stress of anisotropic deformation in sheets and mechanisms made of Al-Li grade 2198 alloys", scientists of the Institute of Metallology of the Chinese Academy of Sciences Zhao Tian-Zhang, Xianlong, Xu Yun, Zhang Shi-hong analyzed the ways of heat treatment of Al-Li alloys and ways to reduce the anisotropic deformation of this alloy. Experiments show that the crystal structure of the alloy and the shape of the granules are the same during refining, and natural wear and anisotropic deformation are also the same in three different directions

* Corresponding author: anvarovichsarvar908@gmail.com

[2-3]. In this research work, the effect of lithium in aluminum-lithium alloy on the mechanical properties of the alloy was studied.

2 Materials and methods

The experiments used aluminum grades such as AK7 and D16, which are widely used in mechanical engineering [4]. Tables 1-2 give the chemical composition of the above aluminum alloys.

Table 1. Chemical composition of AK7.

Al	Fe	Si	Mn	Ni	Cu	Mg	Zn	Others
87.6-93.6	≤ 1.3	6-8	0.2-0.6	≤ 0.3	≤ 1.5	0.2-0.5	≤ 0.5	3.3

Table 2. Chemical composition of D16.

Al	Fe	Si	Mn	Cr	Ti	Mg	Cu	Others
90.6-94.7	≤ 0.5	≤ 0.5	0.3-0.9	≤ 0.1	≤ 0.15	1.2-1.8	3.8- 4.9	0.20

Samples were poured into pre-prepared sand-clay molds. Samples were poured into molds at a temperature of 750 °C.

3 Experiments and results

The weight of the charge in each sample was 130 grams. In experiments, lithium fluoride compound was added in an amount of 5%, 10%, 15% compared to the charge mass. During the study, lithium fluoride compound was introduced into the samples in an amount from 5% to 15% as an alloying element in relation to the total weight of the charge.For comparison, first of all, a sample was poured into which lithium fluoride was not added. The cast samples are shown in Figure 1.

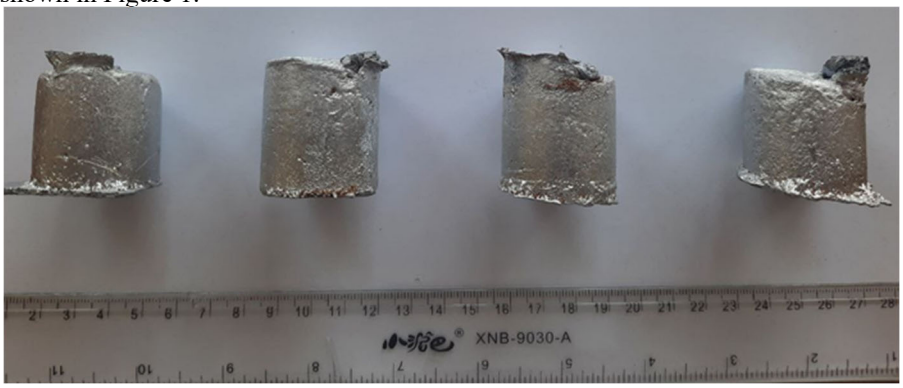

Fig. 1. Cast samples.

The necessary fragments were separated from each sample with the help of a lathe for conducting research. The Rockwell method was used to measure the hardness of the sample. When using this method, the trace of the body immersed in the sample is measured during the immersion process itself, which greatly speeds up and facilitates testing. The Rockwell method is measured on three scales [5-6]. Which scale was used when testing the part or sample, the sign of this scale is added to the right of the HR mark, for example: HRC, HRB, HRA. In the experiments, the EHRA scale and the Rockwell press of the N3A PE model were used to measure hardness (Figure 2).

The samples taken, divided into pieces, were prepared for grinding and measuring their hardness (Figure 3)

Fig. 2. Model N3a PE Rockwell press.

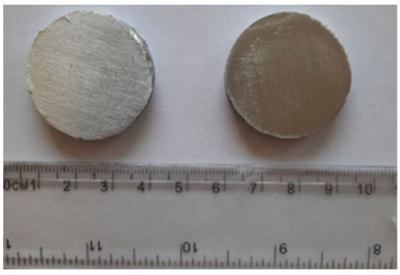

Fig. 3. Finished samples.

The flattened samples were measured on a Rockwell press sequentially from 3 points per sample. The measurement results of the samples are shown in Figure 4.

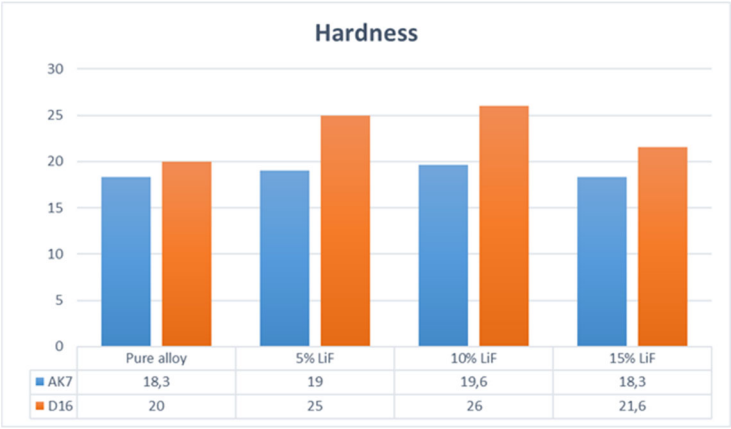

Fig. 4. Sample hardness measurement results.

To determine the abrasive wear resistance, the PV - 7 device was used. The structure of the PV - 7 device is shown in Figure 5. When the screw rotates, it draws abrasive particles

into the gap between itself and the sample, creates it and pulls down the developed abrasive material. The chain is driven by an RD- 09 type motor with a screw and a metering gearbox. The sample itself is cut using a metal cutting lathe in the form of a parallelepiped 45 mm long and 35 mm wide. The thickness of the sample is 5-10 mm [7].

Samples were tested on the device at regular intervals. The mineral corundum (crystalline α-aluminum oxide Al2O3) was used as an abrasive material [8]. Samples were placed on the device 3 times with an interval of 30 minutes, and in each time interval their masses were measured using a scale. The relationship was based on a decrease in mass. Figure 6 shows the results of the solubility determination.

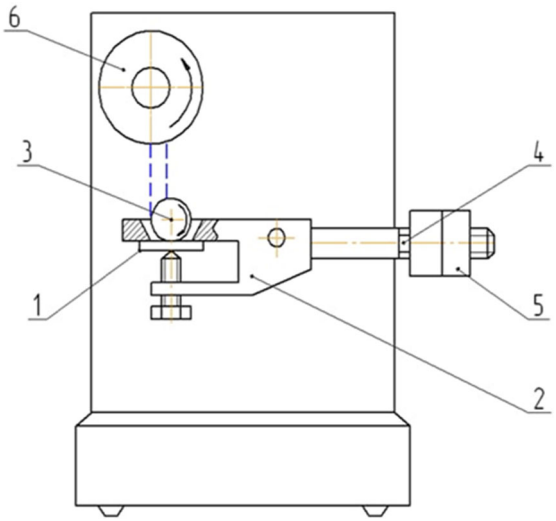

Fig. 5. PV -7 device: 1 - sample; 2-holder; 3 - screw; 4 - handle; 5 -switchable loads; 6-dosing.

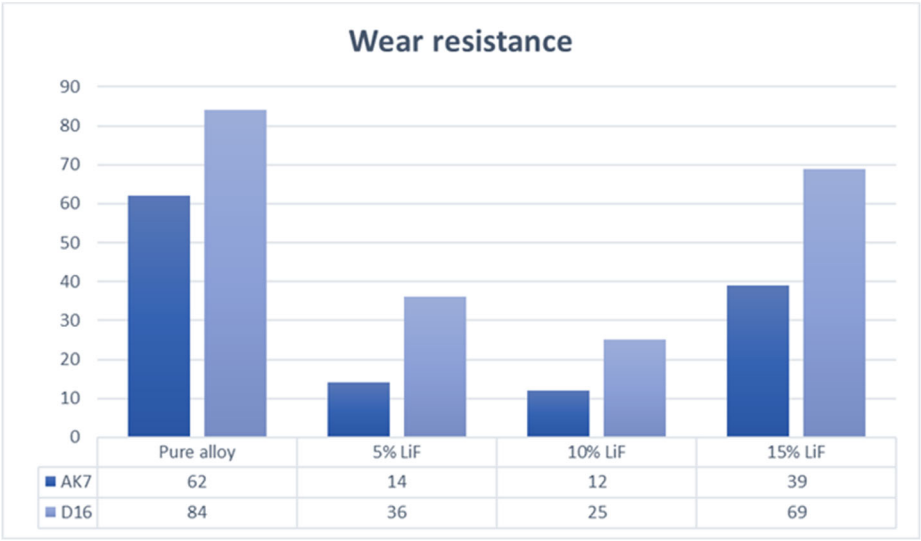

Fig. 6. The results of measuring the abrasive wear resistance of samples under the influence of the mineral corundum.

Based on the identified results, a graph was developed (Figure7).

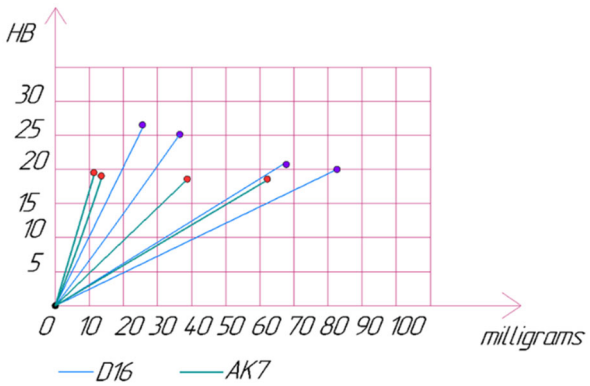

Fig. 7. A graph of dependence.

4 Conclusion

Based on the conducted research, it can be concluded that, a graph of the relationship and impact strength of the obtained aluminum-lithium alloys was developed. It can be seen from the developed graph that experiments show that in samples made with the addition of lithium fluoride compound to the AK7 and D16 brands, the mechanical properties of the compound compared to samples that were not added. Increased hardness from 3% to 7.8% when adding lithium fluoride compound to the AK7 grade in the range from 5% to 10% compared to the charge, however, an increase in hardness in the range from 20% to 28% was found in the D16 brand. And when added in a ratio above 15%, it was found that the hardness of samples of both brands decreases. The abrasive wear resistance of the samples improved from 21% to 32% when lithium fluoride compound was added to the charge mass in a single amount from 5% to 10%.

References

1. T. Nodir, T. Sarvar, K. Kamaldjan, T. Shirinkhon, A. Shavkat, A. Mukhammadali, International Journal of Mechatronics and Applied Mechanics, **2022(11),** 52-56 (2022). https://doi.org/10.17683/ijomam/issue11.7
2. Z. Tian-Zhang, J. Long, X. Yong, Z. Shi-Hong, Materials Science and Engineering: A, **771**, 138572 (2020)
3. S. Tursunbaev, N. Turakhodjaev, S. Turakhujaeva, S. Ozodova, S. Hudoykulov, A. Turakhujaeva, IOP Conference Series: Earth and Environmental Science **1076(1)**, 012076 (2022). https://doi.org/10.1088/1755-1315/1076/1/012076
4. K. Karimov, N. Turakhodjaev, A. Akhmedov, S. Tashbulatov, E3S Web of Conferences **264**, 04077 (2021). https://doi.org/10.1051/e3sconf/202126404077
5. K. Karimov, N. Turakhodjaev, A. Akhmedov, S. Chorshanbiev, E3S Web of Conferences, **264**, 04078 (2021) https://doi.org/10.1051/e3sconf/202126404078
6. Y. Li, J. Wang, R. Wu, Z. Wei, Q. Ji et al, Advanced Engineering Materials **24(8)**, (2022). https://doi.org/10.1002/adem.202101502
7. S. Tursunbaev, D. Umarova, M. Kuchkorova, A. Baydullaev, Journal of Physics: Conference Series **2176(1)**, 012053 (2022). https://doi.org/10.1088/1742-6596/2176/1/012053

8. B. Qian, H. Zheng, R. Wu, L. Hou, J. Zhang, J. Sun, Journal of Materials Engineering and Performance **31(8)**, 6617-6625 (2022). https://doi.org/10.1007/s11665-022-06757-w