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**RESEARCH OF PHYSICOMECHANICAL AND TECHNOLOGICAL PROPERTIES OF ALUMINIUM**

This paper investigates the physical, mechanical and technological properties, the characteristics of high aluminum electro- thermal conductivity, corrosion resistance. The paper presents a table according to GOST 11069-2001 Interstate and 4784-97, which contains the mark, cleanliness and area use of aluminum. The authors analyze the main physical and mechanical properties and stability of aluminum depending on the environment, the degree of purification of primary aluminum, which is separated into aluminum and high technical purity in accordance with (GOST 11069-2001 ) and technical aluminum, which includes the brand labeled AD AD1, AD0, AD00 in accordance with GOST 4784-97, and discusses technical aluminum all grades prepared by melt electrolysis and high purity aluminum obtained additional purification of industrial aluminum . Substantiates the main difference between the practical and technical high-purity aluminum, which is associated with differences in the corrosion resistance in some environments, analyzed the degree of purification of aluminum, the greater the degree, and so it is naturally more expensive in price. In this paper special purposes a high purity aluminum for the production of aluminum alloys, cable and wire productsand rolled products, which is used for industrial aluminum. We consider the effect of chromium, manganese, and titanium on the electrical conductivity of aluminum, designed for the manufacture of current conductors, regulated content has more impurities.

***Keywords***: aluminum, physical-mechanical properties, thermal conductivity, electrical conductivity, technical, aluminum, natural impurities, iron, ductility, corrosion resistance, temperature, recrystallization annealing.

**Introduction**

Physical, mechanical and technological properties of aluminum are very dependent on the type and amount of impurities, compromising most of the properties of the pure metal. To improve the mechanical and processing properties, the aluminum is alloyed with different elements (Cu, Mg, Si, Zn). Iron and silicon are regular aluminum alloy.

**Aluminium** has a high electrical and thermal conductivity, corrosion resistance, ductility, resistance to frost. The most important property of aluminum is its low density (about 2.70 g/cc. Cm). The melting point of aluminum about 660ºC [1].

Physical, mechanical and technological properties of aluminum are very dependent on the type and amount of impurities, compromising most of the properties of the pure metal. The primary natural impurities in aluminum are iron and silicon. Iron, for example, being present as a separate phase, Fe-Al, reducing the electrical conductivity and corrosion resistance, ductility deteriorates, but somewhat increases the strength of aluminum.

**The theoretical calculations**

The equations for calculating the mechanical and technological properties of aluminum have been used to study changes in materials under the influence of temperature - is a necessary condition for establishing the nature of many phenomena and theoretical calculation of stresses and cutting forces. Are provided in the electrical conductivity, mechanical strength, fatigue, creep.

Depending on the degree of purification were separated on aluminum primary aluminum of commercial purity and high (GOST 11069-2001) [2]. For technical aluminum are also brand labeled AD, AD1, AD0, AD00 (GOST 4784-97) [3]. Technical aluminum all brands produced by electrolysis of cryolite-aluminum melts. High-purity aluminum receive additional purification of industrial aluminum.

Table 1 shows the summarized information on most of the grades of aluminum, as well as indicates the content of its main natural impurities - silicon and iron.

Table 1 - Information on the higher grades of aluminum [4]

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Brand mark** | **Al, %** | **Si, %** | **Fe, %** | **Applications** |
| **High-purityaluminum** | | | | |
| **А995** | **99.995** | 0.0015 | 0.0015 | - Chemical Equipment  - Foilcapacitorplates  - Specificobjectives |
| **А98** | **99.98** | 0.006 | 0.006 |
| **А95** | **99.95** | 0.02 | 0.025 |
| **Technicalpurityaluminum** | | | | |
| **А8 АД000** | **99.8** | 0.10  0.15 | 0.12  0.15 | - Wire rod for the production of cables and wires (from A7E and A5E).  - Raw material for the production of aluminum alloys  - Foil  - Hire (rods, strips, sheets, wire, pipes) |
| **А7  АД00** | **99.7** | 0.15  0.2 | 0.16  0.25 |
| **А6** | **99.6** | 0.18 | 0.25 |
| **А5Е** | **99.5** | 0.10 | 0.20 |
| **А5    АД0** | **99.5** | 0.25  0.25 | 0.30  0.40 |
| **АД1** | **99.3** | 0.30 | 0.30 |

The main practical difference between the technical and highly purified aluminum due to the differences in corrosion resistance to certain environments. Naturally, the higher the degree of purification of aluminum, the more expensive it is.

In order to use special high-purity aluminum. For the production of aluminum alloys, cable and wire products used and rental of industrial aluminum.

The most important property of aluminum - high electrical conductivity, for which he is second only to silver, copper and gold. The combination of high conductivity and a low density allows aluminum to compete with copper in the field of cable and wire products.

In addition the conductivity of aluminum and iron greatly affects silicon chromium, manganese, titanium. Therefore, in aluminum for the manufacture of conductors current regulations on the content of several more impurities. For example, in aluminum brand A5E permitted when the iron content of 0.35% and 0.12% silicon, the amount of impurities Cr + V + Ti + Mn should not exceed 0.01% only.

Conductivity depends on the material. Prolonged annealing at 350°C improves the conductivity and conductivity deteriorates cold deformation.

The specific electrical resistance at 20°C is Ohm\*mm2/m or micro Ohm\*m: 0.0277 - annealed wire made of aluminum brand A7E, 0.0280 - annealed wire made of aluminum, and brand A5E 0.0290 - after pressing, without heat treatment of aluminum brand AD0. Thus, the resistivity of the aluminum conductor is about 1.5 times higher than the electrical resistance of copper conductors. Accordingly, the conductivity of aluminum is 60-65% of the electrical conductivity of copper. The conductivity of aluminum increases with decreasing amounts of impurities.

The thermal conductivity of aluminum is approximately 0.50 cal/cm\*с\*Сand increases with increasing purity of the metal. The thermal conductivity of aluminum is second only to silver and copper, three times higher than the thermal conductivity of low-carbon steel. This property specifies the use of aluminum in the cooling radiators and heat exchangers.

Aluminum has a very high specific heat (approximately 0.22 cal/g\*С). This is significantly higher than most metals (copper in - 0.09). The heat of fusion is also very high (about 93 cal/g).

The reflectivity of aluminum is strongly dependent on its purity. For aluminum foil purity 99.2% reflectance of white light is 75% and for the foil with an aluminum content of 99.5% reflectivity is already 84%.

**Test data**

According to the experimental data on the electrical conductivity of aluminum is among the metals ranks third after silver and copper, but due to the low specific weight aluminum has a conductivity, mass unit is 2 times greater than copper. It gives an idea of the economic profitability of the use of aluminum as the material for the conductors.

On aluminum is usually observed pitting. Therefore, the resistance of aluminum and its alloys in many environments is not determined by the change in weight of the samples and the rate of penetration of the corrosion and mechanical properties change.

The presence of iron reduces the resistance to alkalis and aluminum, but does not affect the resistance to sulfuric and nitric acid. In general, the corrosion resistance of industrial aluminum depending on the purity deteriorates in this order: A8 and AD000, AD00 and A7, A6, A5 and AD0, AD1, A0 and blood pressure.

At temperatures above 100°C, the aluminum reacts with chlorine. Since hydrogen is not reacted aluminum, but it dissolves well, so it is the main component gases present in the aluminum. The deleterious effect of aluminum has a water vapor dissociates at 500°C, at lower temperatures the action of steam small.

Aluminum is stable in the following environments: industrial atmosphere, natural fresh water to a temperature of 180°C.

The corrosion rate increases with aeration impurities sodium hydroxide, hydrochloric acid and soda, salt water, concentrated nitric acid, acid sodium, magnesium, ammonium hyposulfite, weak (10%) sulfuric acid solution.

Aluminum is unstable in these environments: dilute nitric acid, hydrochloric acid, dilute sulfuric acid, hydrofluoric acid and hydrobromic acid, oxalic acid, formic acid.

In contact with most technical metals and alloys aluminum serves as the anode and corrosion will increase.

The modulus of elasticity E = 7000-7100 kgf/mm2 for industrial aluminum at 20°C. At higher purity aluminum its value decreases (6700 to A99).

The shear modulus G = 2700 kg/mm2.

The main technical parameters of the mechanical properties of aluminum are given in Table 2.

Table 2 - Main parameters of the mechanical properties of industrial aluminum [1]

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **units** | **deformed** | **annealed** |
| Yieldpointσ0.2 | kgf/mm2 | 8 - 12 | 4 - 8 |
| Tensilestrengthσв | kgf/mm2 | 13 - 16 | 8 |
| Elongationatbreakδ | % | 5 – 10 | 30 – 40 |
| Contractionatbreak | % | 50 - 60 | 70 - 90 |
| Tensile strength at the cut | kgf/mm2 | 10 | 6 |
| Hardness | НВ | 30 - 35 | 20 |

These figures are approximate:

1. For the annealed and cast aluminum, these values depend on the type of industrial aluminum. The more impurities, the higher strength and lower ductility and hardness. For example the hardness of cast aluminum is: for A0 - 25NV for A5 - 20NV, and for high-purity aluminum A995 - 15NV. Tensile strength for these cases are: 8.5; 7.5 and 5 kgf/mm2 and elongation of 20; 30 and 45%, respectively.

2. For the mechanical properties of the deformed aluminum depend on the degree of deformation of the form and dimensions of rolled. For example, the tensile strength is not less than 15-16 kgf/mm2 and a wire 8 - 11 kgf/mm2 for pipes.

However, in any case, technical aluminum is soft and fragile metal. A low yield strength (even for cold-worked rolled metal does not exceed 12 kgf/mm2) restricts the permitted use of aluminum corrosion.

Aluminium has a low creep strength: 20°C - 5 kgf/mm2, and at 200°C - 0.7 kgf/mm2. For comparison, copper, these figures are 7 and 5 kgf/mm2, respectively.

Low melting temperature and the temperature of the onset of recrystallization low creep limit the operational temperature range of aluminum from the high temperatures.

Ductility of aluminum is not impaired at low temperatures, down to helium. By lowering the temperature from + 20°C to - 269ºC, tensile strength increases by 4 times in technical aluminum and 7 times in high purity. The elastic limit thus increases 1.5 times.

Frost resistance of aluminum can be used in cryogenic devices and structures [1].

Below are the basic physical and mechanical properties of alumina [5]:

The atomic mass of 26.98

Density at 20°C, g/cm3 2.7

Temperature, °C:

melting point 660

boiling 2497

Latent heat of fusion, cal/g 92.4

Specific heat at 20°C, cal/(g °) 0.222

The electrical resistivity at 20°C, Ohm mm2/m 0,027-0,030

Modulus of elasticity in tension annealed aluminum kg/mm2 at °C:

20 6000-7000

200 5500

Ultimate, kg / mm2:

annealed 8

strain 15

Aluminum Elongation,%

annealed 30-40

strain 5-10

Hardness HB aluminum:

annealed 13-20

strain 25-35

cast 13-25

Thermal conductivity at 20°C, cal / (cm sec deg) 0.52

Coefficient of linear expansion and 20-100o, 1 / 23.8 degrees. 10-6

The elastic limit annealed aluminum, kg / mm2 3-4

Yield aluminum kg / mm2:

annealed 5-8

strain 12

Shear modulus at 20°C, kg/mm2 2760

Creep strength at 15°C, kg/mm2 5

Reduction of aluminum, %

annealed 70-90

strain 50-60

The compressive strength of cast aluminum, kg / mm2 42

The toughness of cast aluminum, kg m / cm2 14

High ductility of aluminum foil products allows deep drawing, use it for rivets.

Commercial purity aluminum at high temperatures, exhibits brittleness.

Machinability is very low.

Recrystallization annealing temperature of 350-400°C, tempering temperature - 150°C.

Literature:

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4. Chemical composition of primary aluminum in accordance with GOST 11069-74.

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