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CONCLUSION

We can make a conclusion based on the analysis of the data that owing to the suggested outer modification acetone is located on borders of structural formations of polymer, changing their mobility, that allows to intensify solid phase formation due to increase of relative slip of premolecular formations, significant facilitating of process of polymer chains orientation and thus decrease of residual stresses and stability of geometrical dimensions of the final product.

In this way, solving the main problem of treatment with pressure in the solid phase by using the stage of preliminary preparation of blanks, will allow to propose the low cost technology of industrial manufacturing of products made of polymer (including nanocomposite) materials by treatment with pressure in the solid phase and improving the complex of properties of composite polymer materials.

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MECHANICAL PROPERTIES OF ALUMINIUM ALLOYS CRYSTALLISED IN THE CENTRIFUGE

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ABSTRACT

Continuous improvement and technical sophistication of modern machinery and equipment, extreme conditions of process operations dictate strict requirements for structural materials to ensure their high strength, workability and reliability. A perspective way to improve the operational and technological properties of aluminum alloys is various external impacts on the crystallization processes. Such methods of pre- and crystallization treatment of molten metals will allow to get the target structure and mechanical properties of the alloy. This article is devoted to the investigation of the mechanical properties of aluminum alloy grade AD31 crystalized under a centrifugal-gravity field. An external impact on the crystallization processes and mechanical properties of the alloy were induced by the rotation of the container with the molten metal. The container is fixed on a centrifuge rotating in the horizontal and vertical planes. Simultaneous action of constant gravity and variable centrifugal forces results in a strong decrease in strength properties and an increase in the ductility margin of AD31 alloy. In addition, we can single out a certain angular frequency of 30 rpm, at which extreme values of mechanical properties were recorded. Thus, the research results show the opportunity to use the method of centrifugation to control the crystallization process of the molten metal.

Keywords: alloy, mechanical properties, crystallization, centrifuge

INTRODUCTION

Continuous improvement and technical sophistication of modern machinery and equipment, extreme conditions of process operations dictate strict requirements for structural materials to ensure their high strength, workability and reliability. There are various ways for improving the properties of structural alloys [1-5]:

optimization of alloy composition by combination of metal and technological approaches, which will allow to determine the required alloy structure and the way to achieve it;

– physical methods of influence on the crystallization process: electromagnetic and mechanical mixing of the molten metal bath of the ingot, impact of high frequency vibration, ultrasonic treatment of the molten metal, etc.;

– methods of refining and degasification based on the principle of adsorption, as well as modifying the molten metal in order to achieve specified quality indicators and guaranteed operational reliability of products. Increase in the aviation and aerospace systems technical efficiency is associated with the use of materials with high specific strength, specific rigidity and certain factors of safety at operating loads and temperatures. Deformable alloys grade AD – Duralumins (Al-Mg-Cu system) and Avials (Al-Mg-Si system), are widely used aluminum alloys. Rolling and extrusion are common forming methods for deformable alloys, where primary parts shall combine sufficient strength and high plasticity [6-8]. However, ingots produced in strand casting, are characterized by relatively low ductility margin, and lose ductility with subsequent aging due to the release of strengthening phases. As a result, forming processes require additional or intermediate thermal treatment, which leads to increase in cost of production and does not exclude defects.

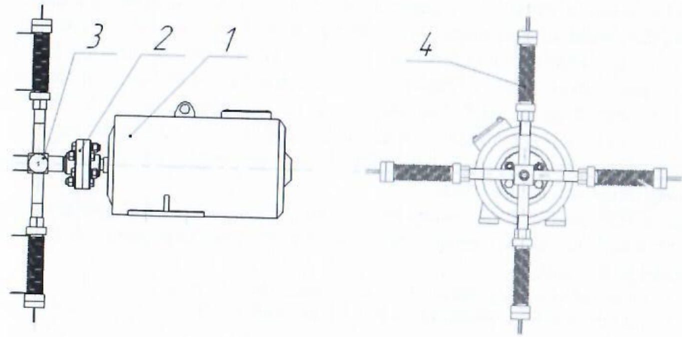
An effective way to improve the operational and technological properties of aluminum alloys is various external impacts on the crystallization processes. Such methods of pre- and crystallization treatment of molten metals will allow to get the target structure and mechanical properties of the alloy. A review of domestic and foreign publications revealed an increased interest in studying the crystallization regularities under various conditions to obtain information on opportunities of alloy synthesis with specified advanced structure and properties. However, there is no consensus on this issue even after a series of metallurgical experiments conducted in space in orbiting space labs.

This article is devoted to the investigation of the mechanical properties of aluminum alloy grade AD31 crystalized under a centrifugal-gravity field.

Materials and Methods of Research

A target of research is deformable AD31 aluminum alloy of Al-Mg-Si system, with Mg content of 0.3 – 0.8 wt.%, Si 0.2 – 0.6 wt.%, Cu < 0.1 wt.%, Mn < 0.1 wt.%. This is a high-ductile cost-effective alloy without expensive alloying elements, characterized by moderate strength and good corrosion resistance.

An external impact on the crystallization processes and mechanical properties of the alloy were induced by the rotation of the container with the molten metal. The container is fixed on a centrifuge rotating in the horizontal and vertical planes [9]. In this case, the mechanical impact on the alloy simultaneously produces a centrifugal and gravity forces under conditions of a smooth temperature decrease. The details of the Experimental Centrifugal Unit are shown in Figure 1.



1 – direct current motor; 2 – coupling;
3 –centrifugal unit; 4 – container

Figure 1 – The Experimental Centrifugal Unit
For the investigation of the mechanical properties of AD31 aluminum alloy

A ceramic container is fixed on each centrifugal blade; it is equipped with a heating coil wound on the ceramic body and terminals for connecting the temperature regulator. There are ampoules with aluminum alloy ingots of equal weight in ceramic cylinders. After heating to a certain temperature, the terminals are disconnected from the current power supply, the electric motor is turned on, and the alloys crystallization takes place in all containers with a gradually decreasing temperature and a variable resultant force affecting the molten metal. A variable-speed unit is provided for smooth adjusting the angular velocity of centrifuge blades.

The research of the thermal and mechanical impact on the strength and ductile properties of AD31 aluminum alloy was carried out during the alloy crystallization under normal conditions (without centrifugation) and during the alloy crystallization with the centrifugation in the vertical plane at a constant angular velocity.

After crystallization in the centrifuge, the alloy billets were used to prepare samples for mechanical tests at monoaxial stretching, with drawing a tensile stress-deformation diagram and calculation of yield point, yield strength and ductility margin.

During the centrifugation, the gravitational and centrifugal forces affect the crystalized body, and the total force varies in magnitude and direction, depending on the position of the container with respect to the axis of rotation. A specific feature of the crystallization in the centrifuge is the stability of the gravitational component during the test. Only the centrifugal force may vary in magnitudes; it depends on the velocity (linear and angular) and the radius of trajectory of the container movement:

$$F_c = mV^2/r = m\omega^2 r,$$

Where F_c – centrifugal force, N;
m – body weight, kg;
V – linear velocity, m/s;
ω – angular velocity 1/s;
r – radius of trajectory, m;

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The linear velocity depends on number of revolutions per minute and the trajectory radius of the container movement. With the unchanged weight of the crystalized molten metal, the magnitude of the centrifugal force can be changed by varying the values of these two parameters. Thus, in case of determining the constant value of the centrifugal force, the centrifuge angular frequency can be a variable factor in the test. The combined effect of gravitational and centrifugal forces causes a variable force-frequency effect on the crystallizing molten metal similar to a wave load with a certain amplitude-frequency characteristic.
This paper represents testing results of mechanical properties of aluminum alloy grade AD31 obtained in a container rotating in a vertical plane, depending on the following parameters of the unit:

- angular frequency varied in the range from 10 to 45 rpm;
- centrifugal force varied in the range from 0.05 to 1.0 N.

Experimental Results

Dependences of ductility margin, yield point, and yield strength on the centrifuge angular frequency increase in the vertical plane are shown in Figures 2-4. AD31 alloy yield point dependence on the centrifugal force is shown in Figure 5.
It was found that with an increase in the centrifuge angular frequency, a stable increase in the ductility of the alloy is observed, which is described by a parabolic curve with a maximum at 30 rpm (Figure 2). With increasing angular velocity, the flexibilising effect of the force-frequency of the unit is removed. The mechanical strength characteristics – σ_s and σ_B vary in reverse way (Figures 3, 4). An increase in the centrifuge angular frequency results in a significant drop in the alloy strength within the range from 10 to 45 rpm. There is a distinct phenomenon of "the alloy force-frequency ductilising and plasticizing." The minimum value of strength corresponds velocity totalling 30 rpm. The yield point decreases most of all, by about 25%, while the decrease in the temporary resistance makes up approximately 5.0%. This result is in good agreement with the data the change in ductility (Figure 2).

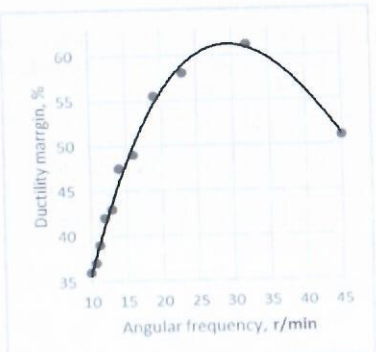

Figure 2 – Dependence of AD31 Alloy Ductility Margin on Centrifuge Angular Frequency

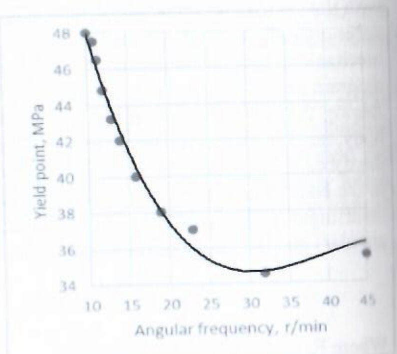

Figure 3 – AD31 Alloy Yield Point Dependence on Centrifuge Angular Frequency

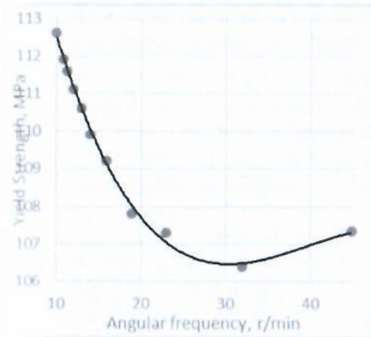

Figure 4 – AD31 Alloy Yield Strength Dependence on Centrifuge Angular Frequency

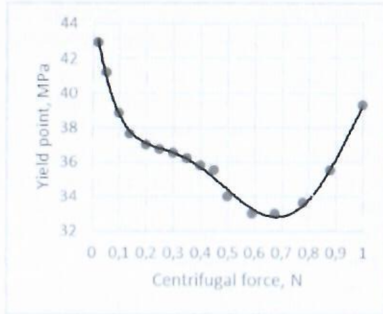

Figure 5 – AD31 Alloy Yield Point Dependence on Centrifugal Force

At high values of angular frequency, a slight increase in strength characteristics and a decrease in ductility are observed. Therefore, we can assume the centrifuge angular frequency of 30 rpm as a critical angular velocity, at which the mechanisms underlying crystallization and structure formation processes are likely to change.
A comparative analysis of the results provided in Figures 2-4 shows that the curve knee point takes place under the following conditions of crystallization: angular frequency n = 30 rpm, trajectory radius r = 0.1 m, and the calculated value of centrifugal force makes up F_c = 0.443 N, at the above figures.
A more complex curve describes the dependence of the yield point on the magnitude of the gravitational force (Figure 5). We can single out several areas with different rate of change thereof, depending on the centrifugal force. With an increase in the centrifugal force F_c up to 0.15 N, a sharp drop in the yield point, by approximately 6.0 MPa is recorded. This area can be characterized as an area of high sensitivity to gravity-centrifugal force. The second area, within the range from 0.15 N to 0.44 N, on the contrary, is characterized by a rather low influence on the yield point. A very sharp ductilising of the alloy is observed in the range 0.44-0.5 N, where the change in the centrifugal force is very slight.
The knee point of AD31 aluminum alloy yield point – centrifugal force curve during the crystallization matches to the centrifugal force of 0.444 N. It is fair to assume that the curve knee point is associated with a change in the direction of the total force projection on the axis of ordinates from the negative (the lower position of the container) to the positive (the upper position). Thus, during the centrifuge rotation, the alternating loads, in terms of magnitude and direction, are applied to the crystallizing molten metal.

CONCLUSION

Simultaneous action of constant gravity and variable centrifugal forces results in a strong decrease in strength properties and an increase in the ductility margin of AD31 alloy. In addition, we can single out a certain angular frequency of 30 rpm, at which extreme values of mechanical properties were recorded. This suggests that this value of

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angular frequency is critical for AD31 alloy, and the crystallization process has a wave nature and is characterized by certain values of amplitude-frequency parameters.

The obtained results are in agreement with the author's point of view [10]. In the author's opinion, the states of any substance in the processes of melting *(crystallization)* and dissolution are associated with certain vibrational modes and strong vibrational-electronic interactions. The author believes that the processes of melting (*crystallization*) are associated with the nonequilibrium excitation of typical vibrational states, which energy considerably exceeds the average energy proportional to kB.

Thus, the research results show the opportunity to use the method of centrifugation to control the crystallization process (crystallization capacity) of the molten metal. The combined action of the gravitational and centrifugal forces during the centrifugation of the crystallizing aluminum alloy has a significant effect on the structure formation and mechanical properties.

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MINIATURIZATION AS A WAY TO PRESERVE MATERIAL IN THE MANUFACTURE OF MICROSTRIP DEVICES

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ABSTRACT

Microstrip devices have found wide application in various fields of radio engineering. However, such devices are made on dielectric substrates from various materials - glass, mica, ceramics, etc. In the process of manufacturing microstrip devices, it is possible to use, as etching method, this removal of excess copper coating, and removal of copper coating with special equipment, for example a milling machine . As a result, at various stages of manufacturing, material waste remains in large quantities, a solution for etching, milling the milling cutter and many other things are consumed. In order to reduce the amount of waste and the total amount of material used, it is proposed to use the miniaturization method, which, through more efficient use of the substrate area, minimizes the cost of producing microstrip devices. Modeling was carried out in the program for electrodynamics analysis of radio electronic devices in the NI-AWR Design Environment program 13. In this paper, a miniature crossover was developed, the dimensions of which were reduced by meta-structures by 70.1% compared to the dimensions of a traditional design, while maintaining characteristics in a wide band of operating frequencies.

Keywords: material, microstrip line, dielectric, substrate, miniaturization.

INTRODUCTION

Various microstrip devices are made on dielectric substrates, for example, antennas, directional couplers, filters, etc. Foiled materials of the microwave range are sheet materials, the basis of which are high-temperature polymers with excellent dielectric characteristics, coating with copper galvanized foil. Depending on the brand of microwave, materials have different dielectric permittivity, but, in general, all are designed for manufacturing printed and strip-printed circuit boards of the microwave range, antenna elements and other microwave products. Using the miniaturization process, it is possible to substantially save material and expenses for its production.

Miniaturization is one of the directions of modern radio electronics aimed at designing devices with significantly reduced overall dimensions, weight, etc. Reducing the size of structures is achieved through the use of new design and technological solutions based on the use of elements that have similar characteristics with conventional microstrip lines, but due to its geometry and interelement links makes it possible to increase the packing density of standard designs. As you know, its size depends on the operating frequency of the device, and therefore the lower the frequency, the greater the dimensions of the device. Consequently, the most relevant for the miniaturization range is the decimeter wavelength range. In this paper, we will show the result of the