The pragmatism of applied temperature analysis to determine the rolling parameters under thermal exposure

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Abstract. The main trend in the development of space materials is the creation of such aluminum alloys, which have a perfect set of characteristics and are capable of providing high performance characteristics of aerospace assemblies. The main direction of the scientific research is the pragmatism of the theory of temperature analysis for determining the parameters of rolling of an aluminum alloy by bringing to a discrete state during isothermal heating. Then it becomes possible to assess the response of the sample material to a change in the temperature of both the internal distribution and the establishment of regularities of materials. Analysis of the kinetic curves and scanning results is performed sequentially, inseparably from each other, obtaining a vivid picture of internal changes in the sample when the external temperature changes.

1. Introduction

The theory of temperature analysis for determining the structures of phases by the method of isothermal discrete (IDS) heating clarifies the essence of stationary temperatures and their diagnostic value for describing the transition structures of the transformation of matter at the joints of temperature intervals[1,2]. The versatility of the IDS method in the study is determined by the fact that with its help it is possible to obtain the internal distributions of the properties on cross- sections of the material of products of almost any composition, regardless of the complexity of the structure of matter.

The innovative thermoanalytical support of the research for metals required the development of appropriate methods and new instrumentation. In this case, the device should include both the registration and measurement of continuous external influences and averaged thermal responses. A similar possibility is realized by methods of discrete analysis. Some applications have already been presented in [3], which made it possible to clarify the direction of the research at this stage. There are three directions in the methods of studying the internal temperature and its distributions. 1. Thermodynamics, which allows you to connect with the study of the phenomena of equilibrium states. 2. Heat and mass transfer, offering ways and methods to find the rate of energy transfer. 3. Materials science, which is directly related to the use of methods of physical and chemical analysis, which are of applied importance [4].

It is important to note that monitoring the controllability of the properties of the material, directly the heating mode (holding temperature), requires physical and physical-mechanical and other types of analysis [5,6], they are carried out both before and after heating. The experiment takes a long time, it is
difficult to perform it during the heating of the sample, since it does not provide information on the nature of the distribution and changes in the properties of the sample. The distribution of the internal temperature of the sample over the stages and rates of internal physicochemical processes is a universal, unique parameter for monitoring material properties [7].

2. Experimental part

Laboratory experiments and studies of the temperature distribution in specimens of different sizes and compositions of aluminum alloys after cold rolling make it possible to judge which mode of IDS heating is necessary during heating. It was noted by G.P Doroshko that the dependence of the density on the external temperature during heating changes according to a periodic law through 343 °C, regardless of the holding time, but only on the temperature. The periodicity was determined relative to stationary temperatures (1) using the example of different materials and substances, on the basis of which the main provisions of the theory of temperature analysis were formulated.

\[(Tπ) 171.5; 514.5; 857.5; 1200.5; 1543.5 °C \quad (1)\]

The density connecting the mass and the volume of the sample depends on the temperature and, if presented in the form of the dynamics of the structures of modifications, it will correspond to the function of the state of matter. In this case, the chemistry of the process corresponds to the method of combining the density diagrams of simple substances (elements, components, and chemical compounds) when clarifying the mechanism of formation of a complex substance from these simple ones.

In our study, a promising, lightweight, highly alloyed aerospace alloy 1420 was chosen. 5 batches of samples were prepared, from cold-rolled sheet with a thickness of 5.2 mm, the initial sample size was 30x50 mm. A comparative option for cold rolling of alloy 1420 is possible when selecting sheets obtained by standard industrial rolling technology. Sheets thinner than 6 mm. were obtained by cold rolling followed by hardening. Before cold rolling, the samples were subjected to thermal exposure in the IDS mode with respect to a number of stationary temperatures (1) and kept in a furnace for 3 minutes. The results are shown in the photo (figure 1-5). Figure 6 shows the microtexture of sample 4.

It is also worth paying attention to the fact that during rolling, the directed action of deforming forces causes rotation of grains and their crystallographic axes in a polycrystalline body along the direction of maximum deformation. It is the rotations of the grains and their crystallographic axes that are accompanied by a change in the symmetry of the order parameter associated with cardinal structural transformations that reduce the critical level of elastic energy absorbed by the crystal lattice. This relaxation effect was taken into account when selecting the degree of reduction in one pass of rolling samples from alloy 1420 [8]. However, it is possible to study the processes occurring, on the contrary, under the influence of heat or in the case of multicomponent systems. This is especially important at the contact between individual alloy components and excess phases along their boundaries [9, 10].

![Figure 1](image1.png)  Sample 1 after cold rolling, preheated to 180 °C (a corner is cut off for samples-preparation of microstructure).

![Figure 2](image2.png)  Sample 2 after cold rolling, preheated to 340°C.
In this experiment, it was found that the temperature of 520°C is a characteristic of changes in matter, a spontaneous tendency to stationarity of temperatures over intervals and the formation of the expected geometric center and beginning in each interval. This serves as a guideline for the selection of appropriate temperatures for heat treatment of sheet material of alloy 1420 before rolling. Thus, by registering the thermal effects when rolling samples to different thicknesses, it is possible to determine those modes of rolling passes that were previously unavailable and had restrictions at the limit of structure fragmentation. The figures show those limiting options when the deformations became larger than the thermal effect of rolling provided for the scanning temperature, the discontinuities were always given and stabilization was observed when stationarity was reached (1) and so that the presented discontinuities were not observed, only those parameters of small deformations were selected that guaranteed the reversibility of the distribution functions. This made it possible to identify the area of parameters of small deformations and to obtain the required sheet thickness.

3. Conclusions
The obtained results of the study of the obtained data on the internal distributions for the alloy of the system from the aluminum-lithium system of alloy 1420 showed that the development of a method for scanning the internal temperature of metals of different composition is promising and in the future require experimental research by comparing them with standard properties upon heating.

A step-by-step scanning measurement will make it possible to draw conclusions about changes in the density distribution functions in the volume. Based on the results of measuring the temperature, it will be known how it changes at each point in the volume over time. Studying the dynamics of properties...
in accordance with the values of the internal temperature will help to track their change in easily measurable parameters of time, the number of passes and temperature during heating.

The cycling of plastic deformation during rolling of samples serves as a guide for the selection of the appropriate temperatures and time of normalized thermal activation and the technological conditions for rolling sheet material of alloy 1420 with reference to the initial thickness.

Discrete approaches make it possible to simplify the processing of experimental data and combine data on different compositions for joint heating. The application of isothermally discrete scanning is possible when the same distribution patterns are found for the internal temperature and heat fluxes as for the density. Density is a resultant property, a consequence of internal physical and chemical processes and reactions that inevitably occur during the excitation of atoms. With the introduction of time, the density is investigated as a kinetic function and only then as a property of the intensity of the distribution of force moments between the crystals of the phases.

It has been experimentally verified that an increase in temperature up to 520°C, by seven degrees from the stationary temperature of 514.5°C, is optimal. At the given temperature the deformations are small and the structures are reversible, which makes it possible to control the development of cracks. Temperature changes are taken as the fundamental factor in the reliability of technology for the production of products in the rocket and space industry.

The application of the theory of temperature analysis to determine the structures of phases in the state of IDS heating, clarifies not only the concept of stationary temperatures, but also their diagnostic value for describing the transition structures of the transformation of matter at the joints of temperature intervals.

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