The use of information technology and mathematical modeling in the development of modes of aluminum alloy

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Abstract. The work is devoted to the application of the correlation analysis method for the study of aluminum cast alloys; or rather, the relationship between the density of a substance and the concentration of chemical elements in it. The purpose of the work is to study the dependence of the density and concentration of chemical elements in aluminum alloys to establish patterns of growth and decrease in material density. The objective of the work is to determine by the correlation method t he presence of a relationship between the density and concentration of elements of chemical composition. The study was performed by the method of correlation analysis using modern software tools, with the help of which the dependencies between the physical parameters of alloys and their chemical properties were searched. The study made a number of important assumptions, detailed in the publication. As a result of the analysis, it was revealed for which metals in the alloys the values can be processed by the correlation method, and the corresponding point diagrams of the values were constructed. Additionally, the accuracy of the research results was determined by using manual and automatic methods. The study concluded that the density of aluminum alloys depends on the concentration of magnesium. It is shown that using the applied methodology it is possible to establish the accuracy correlation between variables and determine the priority of certain additives in the material. The publication is equipped with the necessary tables and figures, as well as detailed explanations for each stage of the study.

Keywords: Correlation, Dependence, Aluminum alloys, Calibration, Concentration, Physical properties, Chemical properties.

1 Introduction

When researching materials, their properties and characteristics are distinguished by parameters, without values of which their use will be useless. There are many different factors that determine such qualities as ductility, ductility, weldability, brittleness, hardness, hardenability and much more. However, the systematization of this knowledge is not feasible and without any certainty I parameters associated with the aggregate as a whole body condition. This article will focus on the physical properties of metals and their alloys.

The physical properties of the body are basic and determine the state of the material or element in a given period of time. The future shape of a particular machine, as well as the reaction to environmental influences, depend on their values, so it is important to remember that when studying the material on the physical properties of a, the accuracy of the calculations is necessary.

Physical properties include many different measurements: from magnetic properties to measurements related to body weight and systematize physical processes in a general structural approach [1-3]. In this article, we shall discuss only one physical parameter - is the density of matter, which expresses the ratio of body mass to its volume.

The aim of this work is to study the dependence of the physical parameter (density) and chemical parameters (concentration of chemical elements) of aluminum alloys in order to establish the pattern of growth and decrease in the density of the material. The objective of the work is to determine the existence of a relationship between the density and concentrations of elements of the chemical composition by the correlation method .Please note that the first paragraph of a section or subsection is not indented. The first paragraphs that follows a table, figure, equation etc. does not have an indent, either.

2 Materials and methods

To begin with, when studying the dependence of density on other factors, we made the following assumption with respect to volume: this parameter will be taken as a constant, and the mass, in turn, will change its parameters due to changes in the basic chemical properties [4-6].

To study the relationship between the main properties, 14 aluminum alloys with different density indices were taken and their chemical compositions were painted (Table 1).

Using the Exel 2007 program , sorting was performed according to the Density column in ascending order, as a result of which the concentrations of chemical elements occupied the corresponding positions (Figure 1).

The chemical compositions of each alloy are subject to differences due to a variety of mining methods and locations. In this regard, one more assumption was made regarding the frequency of the element encountered: the more often the element occurs in alloys, the more accurate the correlation calculations between the main properties will be (Table 2).

Table 1. The chemical composition of aluminum alloys.

No.	Alloy	Density	Fe	Si	Al	Cu	Mg	Zn	Ti	Mn	Zr
1	AL 1	2.75	0.4	0.35	91.575	4.125	1.5	0.05	0	0	0
2	AL 2	2.65	0.75	11.5	86.9	0.3	0.05	0.15	0.05	0.25	0.05
3	AL3	2.7	0.8	5	90.025	2.25	0.475	0.15	0	0.75	0.25
4	AL 4	2.65	0.5	9.25	89.48	0.05	0.235	0.1	0	0.35	0
5	AL5	2.68	0.75	5	91.92	1.25	0.475	0.15	0.075	0.25	0.075
6	AL 7	2.8	0.5	0.6	94.075	4.5	0.015	0.1	0.1	0.05	0.05
7	AL8	2.55	0.15	0.15	89.63	0.05	9.75	0.05	0.035	0.05	0.1
8	AL 9	2.66	0.75	7	91.37	0.1	0.3	0.15	0	0.25	0
9	AL11	2.94	0.75	7	82	0.3	0.2	9.5	0	0.25	0
10	AL13	2.6	0.75	1.05	92.725	0.05	5	0.1	0	0.25	0.075
11	AL21	2.83	0.3	0.25	89.5	5.3	1.05	0.15	0	0.2	0
12	AL22	2.5	0.6	1	86.35	0	11.75	0.05	0.1	0	0.1
13	AL24	2.74	0.25	0.15	93.15	0.1	1.75	4	0.15	0.35	0.05
14	AL25	2.72	0.4	12	82.265	2.25	1.05	0.25	0.125	0.45	0

Source: compiled by the author according to open sources [2].

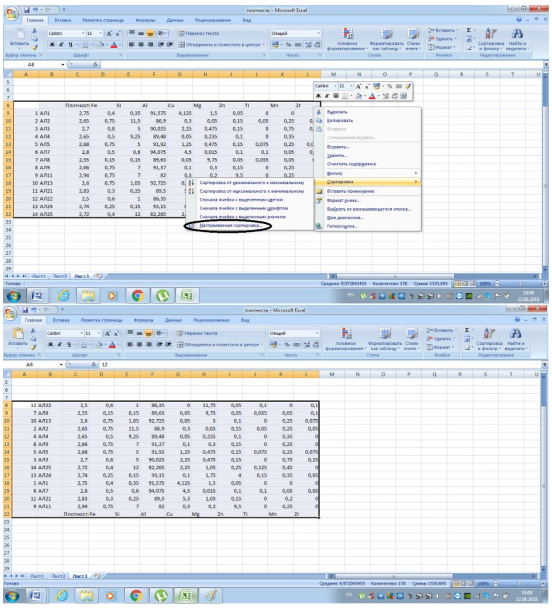

Fig. 1. Sorting data by increasing density.

Table 2. Calculation of the accuracy of the correlation.

The percentage of concentrations that entered the area	Accuracy	Decryption
10-20%	5 qualifications	Accuracy with a very gross error. Indicates no dependence due to a false indicator .
21-40%	4 qualifications	Accuracy with a gross error. Generally indicates the absence of dependence due to a false indicator, but allows some exceptions: in some situations, this dependence will exist
41-60%	3 qualifications	The accuracy of the calculations is normal. Indicates a controversial relationship between variables, allows for both the absence and the presence of dependence.
61-80%	2 qualifications	Good calculation accuracy. Generally indicates a strong dependence between variables, however, an exception is allowed: in some situations, this dependence will not exist
81-100%	1 quality	Reference accuracy of calculations. Indicates a strong relationship between variables.

Source: compiled by the author according to open sources [3].

As a result of the analysis, it was found that the processing of values by the correlation method [7-8] can be performed for iron, silicon, copper, magnesium, zinc a, titanium a, manganese, and zirconium , since for these parameters the error value is less than 50% of all data.

The error value is the ratio of data whose significance is absent, i.e. equal but zero, for all their number. For the most obvious picture, this ratio is multiplied by 100% and a result is obtained that is processed using Table 2. If the error value exceeds 50%, then the calculation of correlation will be less than 50% reliable.

As a result of the selection, the elements that are most likely to be processed are determined by accuracy. Typically, when sorting e values and parameter setting accuracy analyzing workload can with krato in the range from 30 to 45 %. In this case, the workload was reduced by 40 %, since the values of chromium, beryllium, cesium, tin, nickel, and lead have a low accuracy level.

We construct point diagrams of values for elements: iron, silicon, copper, magnesium, zinc, titanium, manganese, zirconium in Microsoft Word 2007. The obtained result must be analyzed from the point of view of the parameter of point concentrations in the diagram area [8-9]. A prerequisite for calculating the relationship between the variables is the accuracy of determining the I correlation area. For this, it is necessary and sufficient to find a region of the diagram that is formed by the largest number of points (Figure 2).

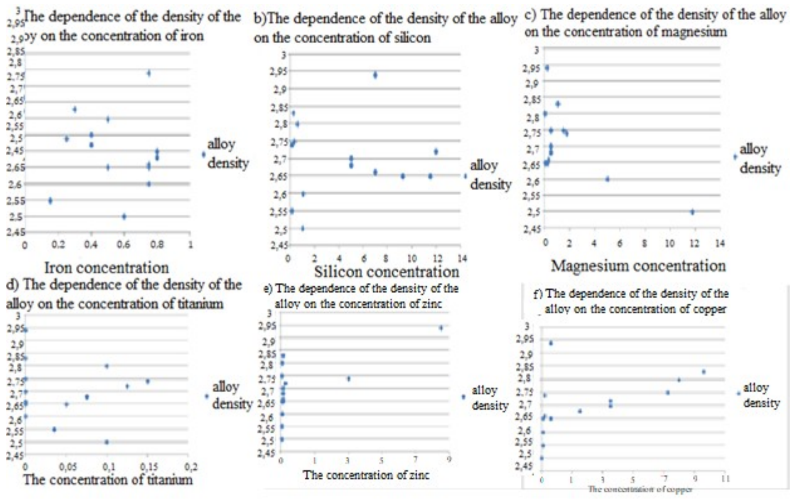

Fig. 2. Determination of the correlation region for metals: a) iron b) silicon c) magnesium, d) titanium, e) zinc, e) copper

After the area has been determined, it is necessary to calculate the correlation index. Its value can be calculated in the following way.

The first step is to determine the area of the ellipse with the highest concentration of points [7]. Inserted elliptical figure in the diagram using calculations region "insert" and then using the editor is invoked m region figures and via points draw axis by a straight line (Figure 3).

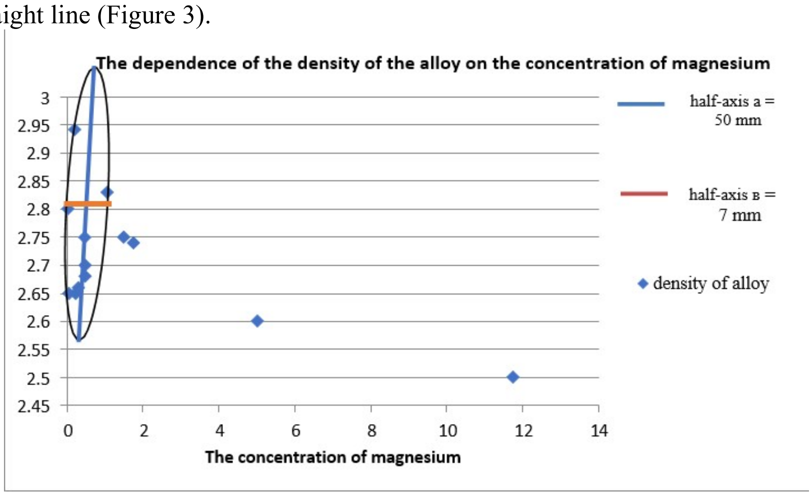

Fig. 3. Determination of the correlation value - the first method.

The constructed ellipse in the diagram area allows finding the value of one or another correlation. To do this, find the ratio of the major and minor axes of the ellipse. Upon completion and calculations, you need to choose the most convenient calibration of the results on a five, ten or stobal scale. After this scale, it is necessary to divide into five intervals and determine the degree of correlation (Table 3).

Table 3. The degree of correlation for the graphical method.

Correlation value	Degree of correlation	Decryption
9-10	5 qualifications	There is no correlation. Dependence does not exist.
8-7	4 qualifications	Correlation is generally absent. Dependence may or may not exist.
5 - 6	3 qualifications	Correlation with controversial nature. Dependence may or may not exist.
4-3	2 qualifications	Correlation exists, but allows some exceptions. The dependency will mainly exist, in some cases it will be absent
2-0	1 quality	Correlation exists and shows the strongest dependence.

3 Results

The result will be positive, if the calibration is, results to determine the same results. Otherwise, there are several reasons:

- Inaccurate determination of the point concentration region;
- Incorrect determination of the axes of the ellipse;
- Error in the mathematical calculation.

When processing data on density and concentrations using an automated and manual method, no errors were detected. The result was the following conclusion: the density of aluminum alloys is strongly affected by the concentration of magnesium and zinc, and to a lesser extent, the concentration of copper (Table 4).

It is known that aluminum and its alloys require a special approach to heat treatment [9]. The thickness of its oxide film is 1-3 nanometers [10], which is not allowed to correctly distribute the temperature on the surface of the alloy. To determine the cause of the increased oxide concentration in the alloy and its reduced density, we use the results of the obtained correlation.

4 Discussion

From table 5 it is seen that the concentration of magnesium has the most pronounced dependence on the density. The curious fact is that a pure magnesium alloy does not exist. It is this alloy that carries a large concentration of oxygen. Confirmation of the reason for the increased oxygen concentration is also the color of metals: with an increased concentration of oxide, the metal loses its luster. In the physical properties of magnesium, it is noted that this alloy in its pure form does not have a luster, as well as aluminum (Figure 4).

Table 4. Results of determining correlation by manual and automated method.

Metal	Manual met hod	Decryption	Automated - ized method (without regard to sign)	Decryption	Total
Magnesi um	7.1	Correlation exists, but allows some exceptions. The dependency will mainly exist, in some cases it will be absent	0.7	Correlation exists, but allows some exceptions. The dependency will mainly exist, in some cases it will be absent	The relationship between the concentratio n of magnesium and the density of aluminum alloys is strong. Allo wed exceptions in some alloys.
Zinc	6.6	Correlation exists, but allows some exceptions. The dependency will mainly exist, in some cases it will be absent	0.63	Correlation exists, but allows some exceptions. The dependency will mainly exist, in some cases it will be absent	The relationship between the concentratio n of zinc and the density of aluminum alloys allows for a strong dependence, but the percentage of exceptions is much higher, since the indicator crosses the boundary between the second and third degrees.
Copper	6	Correlation with controversial nature. Dependence may or may not exist.	0.51	Correlation with controversial nature. Dependence may or may not exist.	The relationship between copper concentratio n and density is controversial . In some situations, the concentratio n of copper will affect the density of the aluminu m alloy, in some situations it will not.

Source: compiled by the author.

Fig. 4. Aluminum and magnesium alloy.

An additional question in the study of correlation analysis was the determination of the accuracy of the method [7-8]. Since the largest number of points in the range was taken as the basis of the method in this study, it can rightly be suggested that there may be several such clusters throughout the diagram; therefore, the analysis method by determining the ratio of the ellipse axes may not be accurate.

Also, the most striking evidence of the fact that the physical properties of aluminum alloys greatly affects the concentration of magnesium , is obtained by us correlation. From the results obtained it can be concluded that aluminum with melting AK7ch grade with a density of 2.66 g / cm^3 has a magnesium concentration of 0.3% in a difference game and from alloy grade AK8 with density w 2.8 g / cm^3 and a magnesium concentration of 0.5% [9]. For completeness of the study will analyze and the remaining two impurities - zinc and copper. Considering copper can be noted the color and ductility, i.e. when a strong correlation can be noted that the alloy with a certain concentration of copper color is slightly yellowish (when mixed with silver and serami shades alloys) and have a high ductility, but the color of aluminum has only light gray shades.

Zinc is a silver-colored metal with increased brittleness, the alloys of which contain a minimum percentage of oxygen and have an expressive metallic luster. As is known, aluminum is not a brittle material, but has a thick oxide film and has an average gloss differences in e from zinc.

5 Conclusion

According to the results of the study it can be concluded that the density of aluminum alloys depends on the magnesium concentration dependence retrograde expressed that this material provides ductility, and difficult processing.

In addition, the Performan study may be mentioned rapid processing of data manual method. Using the methodology used by us, it is possible to establish the quality of correlation accuracy between variables, as well as determine the priority of certain additives in the material.

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